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The Development of Views regarding the Nature of Chemical Forces: PROFESSOR KASIMIR FAJANS 99

Scientific Events:
Historic Apparatus; British Air Route to the Arctic Regions; A Primary Standard of Light; Reforestation during 1929; Yale University and the Bernice P. Bishop Museum; Further Academic Dismissals in Mississippi 107

Scientific Notes and News 110

Discussion:
Conifer Inflorescence: DR. G. R. WIELAND. *The Spectra of Gases Lighted with Strong Electrical Discharges:* DR. E. O. HULBURT. *Scientific Minute Men in Anthropology and Archeology:* WATSON DAVIS. *Two Unusual Flocks of Swans:* NELL A. ROGERS. *Curiosities of Scientific Names:* JOHN C. GIFFORD 113

Special Correspondence:
The Advancement of Geology through Cooperative Research: DR. W. TAYLOR THOM, JR., and DR. RICHARD M. FIELD 117

Scientific Books:
Larmor's Mathematical and Physical Papers: PROFESSOR LEIGH PAGE. *Hackh's Chemical Dictionary:* PROFESSOR W. A. NOYES. *Tiffany on the Oedogoniaceae:* PROFESSOR WM. RANDOLPH TAYLOR 118

Scientific Apparatus and Laboratory Methods:
A Manifold Desiccating Apparatus for Determining the Dry Weight of Small Samples of Wool: PROFESSOR JULIUS E. NORDBY. *The Preparation of Permanent Slides of the Rhizopod Arcella:* DR. C. DALE BEERS 120

Special Articles:
Actino-uranium and the Ratio of Actinium to Uranium in Minerals: PROFESSOR ALOIS F. KOVARIK. *On the Mechanism of Biological Oxidation and the Function of the Suprarenal Gland:* DR. ALBERT SZENT-GYÖRGYI 122

Science News x

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THE DEVELOPMENT OF VIEWS REGARDING THE NATURE OF CHEMICAL FORCES[1]

By Professor KASIMIR FAJANS

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AT the beginning of my lectures before the department of chemistry of Cornell University, I wish to express my great pleasure at having the opportunity to spend a few months in this wonderful laboratory, beautifully situated on a knoll of the picturesque campus, and to come into close personal contact with my distinguished colleagues as well as with the students. I am sure to learn many things from the splendid organization of this department which will be of great use in my own institute. I thank Professor Dennis heartily for the honor of his invitation to the George Fisher Baker Non-resident Lectureship and for the opportunities he thus affords me.

It is a pleasant custom that the holder of this lectureship begins his activities with a general address for a wider circle of listeners than will attend his later lectures in his special field. Several of my predecessors have chosen for this introductory lecture subjects that were more or less far removed from the particular lines of their own research. If you will permit me, I will join the other group and discuss a problem which lies in my own field, for I regard the problem of chemical forces as one that may be of interest not alone to the specialist but to the general public as well. These forces affect deeply not only the surrounding, inanimate world but also the life processes within our own organism, and I shall endeavor to present to you the problem of their true nature.

This question has greatly interested theorists for many centuries. Let me briefly recount at least a few of the steps in the older development before I pass on to the discussion of the views that are held at the present time. There is a characteristic trend that has been common to most of the various theories which have arisen. Chemistry, as you know, serves as a

[1] Introductory public lecture.

basis of many other sciences, such as mineralogy, crystallography and biology, and chemistry in turn rests in many respects upon the results obtained in physics. And we shall see that the views concerning the nature of chemical forces in the passage of time often have been modified and shaped by the physical theories of the moment.

In the seventeenth century there was great development in the field of mechanics. It is necessary to mention only the names of Galileo, Kepler and Newton to make clear the powerful influence that mechanics exerted upon the concepts of that period. Even a century later, explanations of phenomena were expected to be based upon mechanical processes. As early as the seventeenth century the French chemist Lemery, in an attempt to explain the action of an acid on a metal, sought for a mechanism upon which its chemism might be based.

The sensation of taste that is produced by acids can be described as biting or prickling, and it was quite natural, from the point of view of a crude mechanical concept, that when a metal is dissolved by an acid the small particles of the acid were assumed to possess a pointed form which would bore into the cavities of the metal. Naturally such a concept can not be recognized as a sound scientific theory. In general the mechanical ideas have not proved to be fruitful in explaining chemical phenomena. To enable the particles of an acid to act upon a piece of metal, the particles of acid dissolved in water must by virtue of their motion in the liquid come into the immediate neighborhood of the metal. Thus far, the process can be clearly conceived as mechanical, but the real chemism begins only when the reacting particles of the acid and metal collide with one another, and at this point the bridge to the usual mechanical explanation is lacking.

It is interesting to note, however, that to-day mechanics is again beginning to come into closer relationship with what is essentially chemical action. This newer view is based not upon the classical mechanics of the seventeenth and eighteenth centuries, but on the refined, modern theory of wave mechanics or quantum mechanics associated with the names of de Broglie, Heisenberg and Schrödinger. We must, however, ascend through several stages to pass from the mechanical chemistry of a Lemery to this latest view.

When we leave the field of mechanics we enter at once another branch of physics, electricity, which we must consider if we are to understand the views advanced by the great Swedish chemist Berzelius in the early part of the nineteenth century. By that time two fields of knowledge had been developed that are of permanent value for our problem. There was brought forward a more exact conception of the building up of substances from small particles, an idea familiar to the Greeks. Dalton developed the atomic theory which required the existence of as many different atoms as there are non-decomposable elements, the smallest particle of a chemical compound, the molecule, being composed of one or more elemental atoms. The question at once arose: What forces hold these atoms together in the molecule?

The answer to this question appeared to be brought nearer because, in this period, it was found possible to overcome these attracting forces by means of a new and powerful agent, the electric current. At the end of the eighteenth and the beginning of the nineteenth centuries there appeared the epoch-making discoveries of Galvani and Volta as to the manner of producing an electric current. With the aid of the current, Davy was able to bring about sensational chemical reactions such as the separation of caustic soda into metallic sodium and oxygen. This was a decomposition of a chemical compound into its elements, a splitting of a molecule into atoms with the help of electricity.

Analysis of this phenomenon of electrolysis seemed to indicate a close relationship between electricity and the various kinds of atoms. Distinction had long been made between positive and negative electricity, and the new discoveries by Davy and others indicated that many elements, such as the metals and hydrogen, behaved during electrolysis as if their atoms carried positive charges, while the atoms of chlorine, oxygen and similar elements seemed to be negatively charged. But positive and negative electricity exert an attractive force upon each other, while charges of the same sign repel each other. This brought Berzelius to the idea that the chemical force which binds the oxygen atom either to the sodium atom in an alkali or to the hydrogen atom in the water molecule is of an electrical nature and is dependent simply upon the attraction of oppositely charged atoms as represented by the following slightly modernized formulas:

Berzelius (1812)

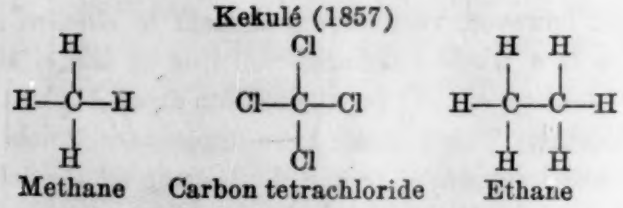
$$\overset{+}{Na_2}\overset{-}{O},\quad \overset{+}{Na}\overset{-}{Cl},\quad \overset{+}{H_2}\overset{-}{O}$$

This conception of the electrostatic nature of chemical forces Berzelius sought to extend to all chemical substances. He held that each atom contained an excess of either positive or negative electricity, and that because of this fact an atom is able to combine with oppositely charged atoms. Indeed, this electrostatic theory of Berzelius seemed to be satisfactory in explaining the behavior of many substances, and it was used by chemists as long as their researches were limited chiefly to inorganic compounds. But about the middle of the nineteenth century a new branch of

chemistry blossomed into life—organic chemistry. This concerned itself with the substances found in animate nature, compounds whose most important constituent is carbon. Among the simplest of such compounds we have methane (CH_4) and carbon tetrachloride (CCl_4). Both these substances are stable compounds in which the atoms are held together by strong forces. If now one endeavors to explain these attractive forces on the basis of the theory of Berzelius, contradiction concerning the charge on the carbon atom immediately appears. According to the evidence furnished by the electrolysis of inorganic compounds, hydrogen is positively charged, from which it follows that the carbon atom in CH_4 should carry a negative charge. Yet in CCl_4, since chlorine is shown by electrolytic experiment to be negatively charged, the carbon atom should have a positive charge. Such contradictions, which arose in many analogous cases, led to the conviction that the electrostatic theory of Berzelius was untenable, and therefore chemists gradually abandoned it. We shall see later that this theory did nevertheless contain a germ of truth.

In order properly to follow the historical development of the subject, however, we must now leave the field of physics and turn our attention to a theory that forgoes definite assertion concerning the physical nature of chemical forces and contents itself with a formal representation of the union of atoms in molecules. I refer to the valence theory advanced in 1857 by the German chemist Kekulé. Kekulé represented the union of the atoms in the molecule by means of lines, the maximum number of other atoms with which a given atom may combine being represented by the number of lines proceeding from it. This number is termed the valence of the atom. The carbon atom has a valence of four, the atom of hydrogen and that of chlorine in carbon tetrachloride each has a valence of one.

Kekulé (1857)



Methane Carbon tetrachloride Ethane

It is a strikingly primitive picture that is used here to represent the chemical forces, and yet it confirms in most convincing manner the truth of Goethe's words, *In der Beschränkung zeigt sich erst der Meister,* for the scheme of Kekulé has proved to be extremely fruitful in chemical research up to the present day, and in particular in the field of the chemistry of the compounds of carbon. We find in almost every case that the carbon atom possesses four of such valence forces, four units of chemical attraction each of which is able to seize and hold an atom. The constancy of this number 4 in most of the carbon compounds constitutes the great, although purely systematic, value of Kekulé's suggestion.

From the physical view-point Kekulé's theory stands in some contradiction to that of Berzelius. On the basis of the Berzelius theory one can also draw lines between the atoms that he regarded as oppositely charged and as electrostatically bound. Such connecting lines would then have a positive and a negative end. One positive atom can be replaced only by a positive atom. The link would be polar. According to Kekulé, on the other hand, atoms of widely varying nature can be attached to the outer ends of the valence forces emanating from the atoms of carbon, and this stands in agreement with the facts of organic chemistry. Thus the carbon atom may attach itself to other carbon atoms, as is shown in the above formula of ethane. The linkage is here non-polar. Specially convincing illustrations of the existence of such non-polar linkages are found in the molecules of certain elements: the molecule of ordinary gaseous hydrogen (H—H) and also the molecule of chlorine (Cl—Cl) are each composed of two atoms. In such molecules there is no reason to assume that one atom carries a positive and the other a negative charge. The above successful application of Kekulé's scheme to inorganic molecules also seemed to justify its use for representing such compounds as sodium chloride, for which the theory of Berzelius seemed to be quite satisfactory. Until recently this has been written as Na–Cl without endeavoring to bring out the opposite polar character of sodium and chlorine as revealed by electrolysis. As may so often be observed in the history of the development of scientific theories, a leap from one extreme to the other here took place. Both theories attempted to reach the same goal and to explain the linkages of the atoms in all substances in a uniform manner. Further developments, however, showed that this could not be achieved in so simple a way.

In the last decade of the past century there appeared a new branch of chemistry, physical chemistry, associated with the older branches, inorganic and organic chemistry. The difference between physical chemistry and these two older divisions does not lie in the nature of the substances that are employed in the sphere of its investigations, for it concerns itself both with inorganic and organic compounds. However, the method of research used in physical chemistry, which was indeed only partially novel, lays particular emphasis upon the study of chemical compounds and reactions from the standpoint of physics. The electric current was again invoked for the inves-

tigation of the behavior of substances but not alone for the purpose of effecting chemical decomposition. The question as to whether various substances when dissolved in water are capable of conducting the electric current was very carefully studied and striking differences were found to exist. Aqueous solutions of compounds such as ordinary salt conduct the electric current very well. In order that conduction of the current may take place, however, charged particles must be present. It was Arrhenius who, in the year 1887, brought forward the theory, at that time regarded as extremely bold, that in such a solution of salt the molecule NaCl decomposes into a positively charged sodium atom and a negatively charged chlorine atom, the so-called ions. This concept of Arrhenius may to-day be regarded as fully verified. From this it would follow that when a solution of salt is evaporated and the water is removed the ions are brought closer together from the relatively greater distances that existed between them in solution, and the electrostatic forces between them must become active in some manner, since according to Coulomb's law the intensity of the electrostatic force is inversely proportional to the square of the distance between the charges. On the other hand, a substance like H_2 in aqueous solution does not conduct the current to any noticeable extent and consequently there is no reason for assuming the existence of ions of hydrogen in this solution.

These facts have led us since the beginning of this century (Abegg, Nernst) to distinguish between two different kinds of chemical linkages: on the one hand the polar linkage, also termed hetero-polar or dualistic linkage, which is characteristic of salts, and on the other hand the non-polar, homo-polar or unitary linkage, which is characteristic of the molecules of elements and of many organic compounds. And thus we can understand why the dualistic theory of Berzelius could maintain itself only so long as the investigation of organic compounds was not the center of interest. However, the unitary theory of Kekulé which replaced that of Berzelius also does not satisfactorily explain all the phenomena with which we have become acquainted. Both theories are entitled to exist side by side.

The theory of Berzelius in its original form was very weak in one respect; it assumed, for example, that the sodium atom and the chlorine atom always carry an excess either of positive or negative electricity. This, however, is not in agreement with the facts, for metallic sodium as well as its free atom in sodium vapor under normal conditions is electrically neutral. The same holds true for chlorine. The question arises, therefore, as to the manner in which the positively charged sodium ion and the negatively charged chlorine ion present in the solution are formed from these neutral atoms.

A satisfactory answer to this question was possible only after we had obtained a deeper insight into the nature of the atom itself and had acquired the knowledge that the atoms of the elements are not really the indivisible building-stones from which the material world is constructed. Physical research which began with the investigation of cathode rays and the rays from radioactive substances, and with which the names of Lenard, J. J. Thomson and Rutherford are intimately connected, revealed that the atoms of all elements are themselves composite structures and are in the last analysis made up of positive and negative electricity. These electrical charges have an atomistic structure; the magnitude of the smallest charge, the elementary electrical quantum, was measured by your countryman, Millikan, in his brilliant investigations. The charges of these elementary quantities of positive and negative electricity are equal and differ only in sign.

According to the Rutherford-Bohr theories of atomic structure, the atoms of all elements are composed of these atoms of positive and negative electricity. The simplest and lightest element, hydrogen, contains in its neutral condition one elementary quantum of positive electricity and one of negative electricity. The two do not, however, play precisely the same rôle, because their masses are not the same. The elementary negative charge, termed an electron, possesses a mass only 1/1830 that of the total mass of a hydrogen atom. The remainder of the mass lies in the positive charge. The lighter electron revolves around the heavy, positively charged nucleus of the hydrogen atom, the proton, and because of this fact the two attracting charges do not fall together but remain at a definite distance from each other, as do the sun and its planets.

When we consider the heavier atoms we find that they also contain a positively charged nucleus, whose charge, however, varies from element to element and always is a whole-numbered multiple of the elementary quantity, *e.g.*, 11 for the sodium atom, 17 for that of chlorine. These nuclei have dimensions which are very small compared to the dimensions of the whole atom even in the case of the heaviest atoms. The negative charge in the heavier atoms is divided among a corresponding number of negative electrons, and this number in the neutral state is therefore 11 for sodium and 17 for chlorine. All these electrons move in more or less complicated paths around the nucleus.

How now are the ions formed from such neutral atoms? Since, as has been mentioned, a positive elementary charge carries practically the whole mass of

a hydrogen atom and such positive charges are localized in the nucleus of the heavier atoms, the removal of one or more positive charges from an atom would deeply affect its internal constitution and would mean a conversion of one element into another such as we have actually observed in the radioactive processes. The chemical processes, as well as the formation of ions from neutral atoms, take place only in the outer sphere of the atom, in the electron shells. A positive ion is formed when one or more electrons are removed from a neutral atom, for then the positive charge of the nucleus will exceed the total negative charge by the number of negative electrons removed. Negatively charged ions are obtained by attaching one or more electrons to a neutral atom. The process of forming a molecule of the sodium chloride type from neutral atoms is therefore most simply understood by assuming that an electron is removed from a sodium atom and attached to a chlorine atom; the electrostatic attraction of the resulting positive and negative ions then unites them into a molecule or, if they are present in larger number, into a crystal of the salt.[2] This is the essential content of the electrostatic theory of polar linkage outlined by J. J. Thomson in 1904 and especially developed by Kossel in 1916. It represents the modernization of the Berzelius theory.

As far as the other type of linkage is concerned, we are indebted to the idea of Niels Bohr, which shows how it can be brought about by the electrical interaction of positive and negative charges in the atom without the necessity of assuming oppositely charged ions in such molecules and crystals. Let us consider the simplest non-polar molecule, that of hydrogen. It contains two atoms of hydrogen, and accordingly, two positive nuclei and two negative electrons. The mechanism for its constitution (see Fig. 2a) suggested by Bohr, was as follows. The two electrons move along a path whose plane is perpendicular to the line joining the two nuclei. The positive nuclei are held together by the negative electrons, which draw them toward the middle even though the positive nuclei mutually repel each other.

This model has not proved satisfactory from the quantitative point of view, and it is now assumed that the true structure of the hydrogen molecule approximates more closely that shown in a model designed by Heitler and London (1927) on the basis of the wave mechanics referred to at the beginning of this lecture. According to this newer view, the electrons perform such complicated motions within the atoms and the molecules that, in the course of time, an electron passes through every point of the space occupied by the atom or molecule, although the probability that an electron will arrive at any given point depends upon the distance of the point from the nuclei. Therefore, it is only possible to indicate a time average of the spatial distribution of the negative electricity. From the results obtained in this direction, it is particularly important for the discussion that is to follow, that this distribution of the negative electricity with reference to the nuclei of the two linked hydrogen atoms be quite identical, and in this respect the wave mechanics model and that in Fig. 2a are in perfect agreement. In both models also each of the electrons is, in fact, as often at a given distance from the one nucleus as it is from the other.

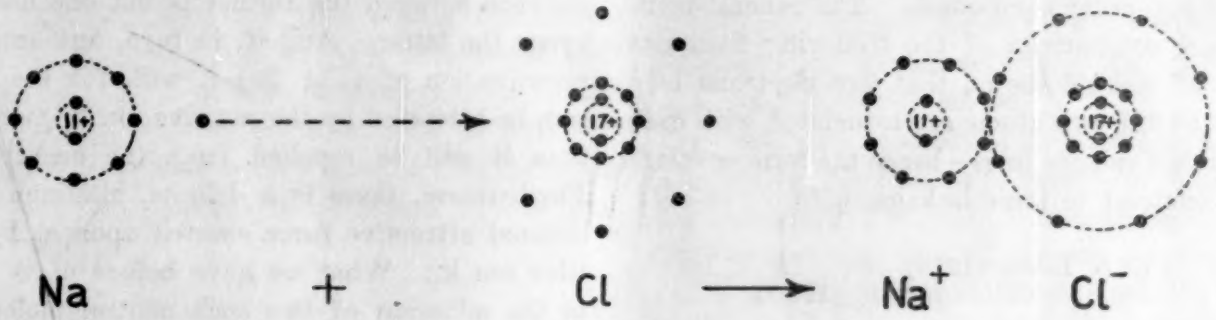


FIG. 1

[2] Of great interest in this connection is the fact that both ions contain eight electrons in the outermost shell, like the rare gases neon and argon.

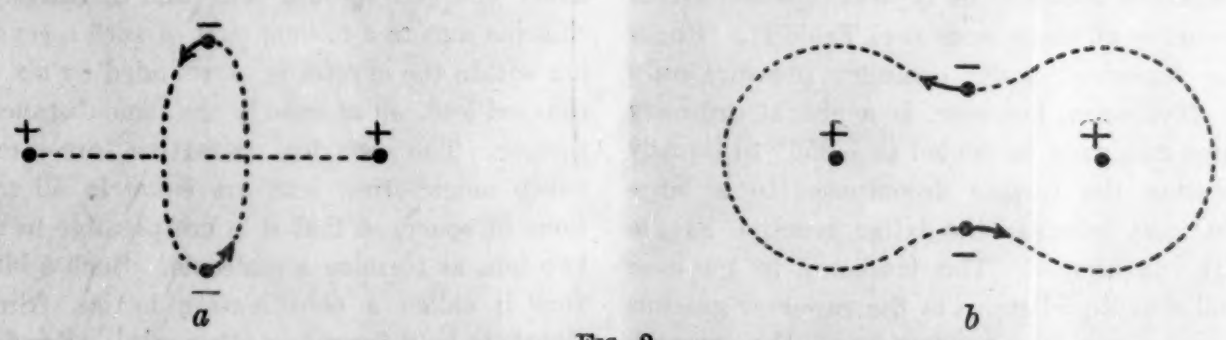


FIG. 2

The relation between nuclei and electrons in the new model may be represented in a simplified way, sufficient for our purpose, by considering that the two electrons describe a path around the two nuclei, as indicated in Fig. 2b, and as has been assumed by a number of investigators in the past, particularly by Knorr (1923). The characteristic point common to all models proposed is, then: the linkage is effected by two electrons which are shared by both atoms in an identical manner. Here there is actually no polar contrast between the two bound atoms, and each contributes one electron to the linkage.

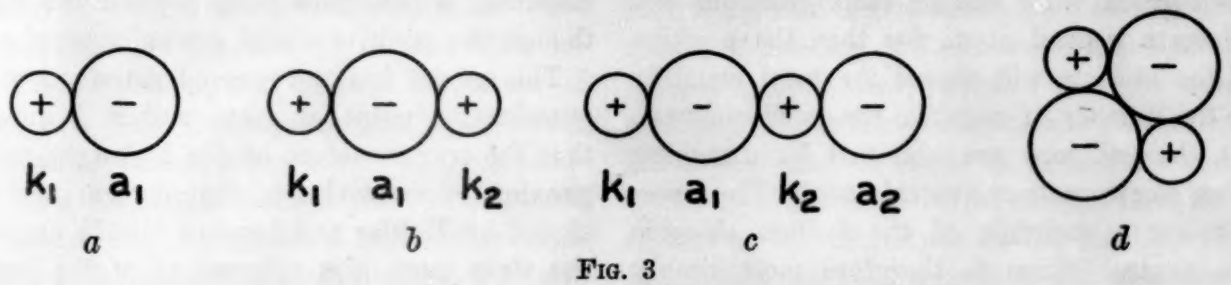


FIG. 3

As has been shown very successfully by your countrymen, Lewis and Langmuir, this principle is also applicable to the molecules of other elements and to many other non-polar compounds. The general principle is, as a comparison of the following formulas with those of Kekulé shows, that two electrons held in common by the two atoms are associated with each one of Kekulé's valence lines—hence the term covalent linkage in contrast to ionic linkage.

G. N. Lewis (1916)

H H : C : H H	Cl Cl : C : Cl Cl	H H H : C : C : H H H
Methane	Carbon tetrachloride	Ethane

The chemical and physical behavior of both types of compounds stands in good agreement with the above conceptions of their structure. We will mention here three properties: the type of lattice in which the substance crystallizes; the ease with which it passes from the solid or liquid to the gaseous state, *i.e.*, its volatility and the ability to form ions in aqueous solution and therefore to conduct the electric current. In this respect extremely large differences may be mentioned between the typical representatives of the two classes of compounds (see Table I). Rocksalt can be vaporized under ordinary pressure only at 1440°. Hydrogen, however, is a gas at ordinary temperatures and must be cooled to −253° to liquefy it. In solution the former decomposes to a large extent into ions, whereas the latter remains as the molecule H_2 unchanged. The tendency to go over from the solid or liquid states to the vapor or gaseous state and *vice versa* is dependent upon the strength of the forces between the molecules. The attractive forces between the molecules of NaCl must, obviously, be much greater than those between the molecules of H_2. Indeed, even though the molecule NaCl is electrically neutral as a whole, it exerts, as the schematic representation in Fig. 3 indicates, a considerable electrical effect in its immediate neighborhood, because in this molecule the centers of gravity of the positive and negative charges, two poles (Fig. 3a), are separated. If one brings a positive ion k_2 to such a structure, which one calls a dipole, it will be attracted to the negative ion in the position which is indicated in Fig. 3b. The attractive force between the opposite charges a_1 and k_2 is greater than the repulsive force between the like charges of k_1 and k_2, because the distance between the former is but one half that between the latter. And if, in turn, one now adds the negative ion a_2 (Fig. 3c) it will, for the same reason, be attracted by the positive ion k_2 more strongly than it will be repelled from the negative ion a_1. Furthermore, there is a definite, although weak, additional attractive force exerted upon a_2 by the positive ion k_1. What we have before us is equivalent to the adhesion of two such neutral molecules, k_1a_1 and k_2a_2, as a result of electrostatic forces which are completely comparable with those which effect the cohesion of the ions within the molecule. Something entirely analogous holds for the action in the other two directions of space (Fig. 3d), and this explains, as shown by Kossel, the great tendency of the molecules of such salts to group themselves in large complexes and to form liquids and crystals. The validity of this view is attested by the recent determinations of the position of atoms and ions within such crystals by means of X-ray analysis. In Fig. 4 is portrayed the crystal structure of rocksalt. The individual points show the positions of alternate, positively charged sodium ions and negatively charged chlorine ions in a minute part of such a crystal. Each ion within the crystal is surrounded by six oppositely charged ions, all at exactly the same distance from the former. The electrical attractive forces existing between neighboring ions are equal in all three directions of space, so that it is not possible to regard any two ions as forming a molecule. Such a lattice therefore is called a coordination lattice. Similar relationships hold for many other salts. (See footnote 3.)

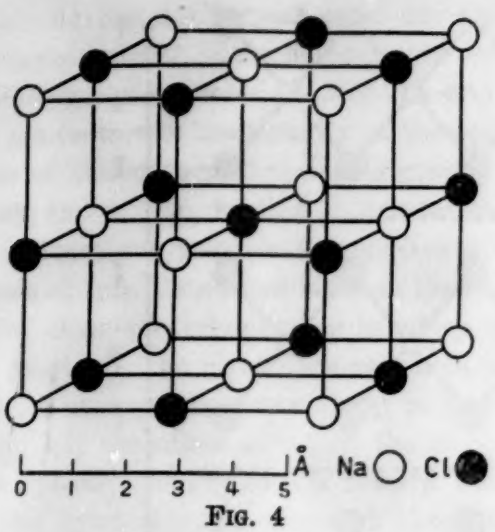


FIG. 4

The circumstances are entirely different in the case of H_2. Here the centers of gravity of the positive and negative charges coincide, so that as long as no shift of the charges takes place in the molecule, no electrical forces can be exerted on the outside. Hence, there is but a slight tendency for the H_2 molecules to combine with one another to form a liquid or solid. And there can be no doubt that the crystal structure of solid hydrogen is quite different from that of rock-salt. Corresponding to the very strong forces between two hydrogen atoms within the molecule and the very weak forces between distinct molecules, the distances between the atoms belonging to different molecules must be considerably greater than between those within one molecule, as indicated in the dia-

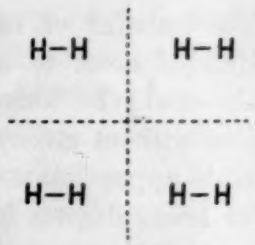


FIG. 5

gram (Fig. 5). Here we have individual molecules in the crystal lattice, and therefore we term it a molecule lattice.

Finally, the great difference between NaCl and H_2 with respect to the third property as given in Table I, *viz.*, the degree of their ionizations in aqueous solution, is readily understood without special discussion. Indeed, in the case of NaCl, the molecule and the crystal already contain ions and they need only to be separated by the action of the forces between the water and the ions, while in the case of such non-polar substances as H_2 energy first must be expended in order to form ions by shifting electrons to one of the atoms.

In such cases as that of sodium chloride and hydrogen, the relations are obviously quite clear. There is here not the least doubt concerning the group to which we must assign the substance, the ionic or the covalent non-polar type of compounds or linkages.

TABLE I

	Ionic linkage	Non-polar linkage	Transition type
Type of lattice	Na^+Cl^- Ionic coordination lattice	H : H Molecule lattice	I Hg I Layer lattice
Boiling-point at 760 mm	1440°	−253°	351°
Degree of ionization in aqueous solution	high	zero	very low

It is immaterial whether we choose as our criterion the volatility, the type of lattice or the ability to dissociate in solution. The same holds for many other substances, and there is a wide-spread tendency to classify all substances under one or the other of these two types of linkages. However, there is a very large number of compounds for which this classification is so indefinitely indicated that it is impossible to apply it with any certainty, and naturally one finds differences of opinion regarding the type of structure to which they really belong.

An example is afforded by mercuric iodide, whose behavior with reference to volatility, crystal structure and ionization in solution is intermediate between that of hydrogen and that of sodium chloride. Mercuric iodide is solid at ordinary temperatures but boils at 351°, and may be vaporized with relative ease similarly to the closely related mercuric chloride, popularly termed corrosive sublimate. Both compounds have a low solubility in water as compared with sodium chloride and, what is here of particular importance, their degree of ionization is measurable but very small.

Of particular interest is the structure of the crystal lattice of mercuric iodide (see Fig. 6a). The characteristics of this lattice that are essential to our problem are emphasized in Fig. 6b which is a simplified presentation in one plane. It is seen that the two kinds of atoms are arranged in alternating layers —hence the type name proposed for it by Hund, "layer lattice." Just as in the lattice of sodium chloride, and in contrast to a molecule lattice, no individual molecule HgI_2 can be differentiated here. Each Hg is linked in an identical way with four, not with two I's; and each I is linked, not with one but with two Hg's. In another respect, however, this layer lattice recalls a molecule lattice more than it does an ionic coordination lattice. In the latter each ion has attracted for its immediate neighbors, on every

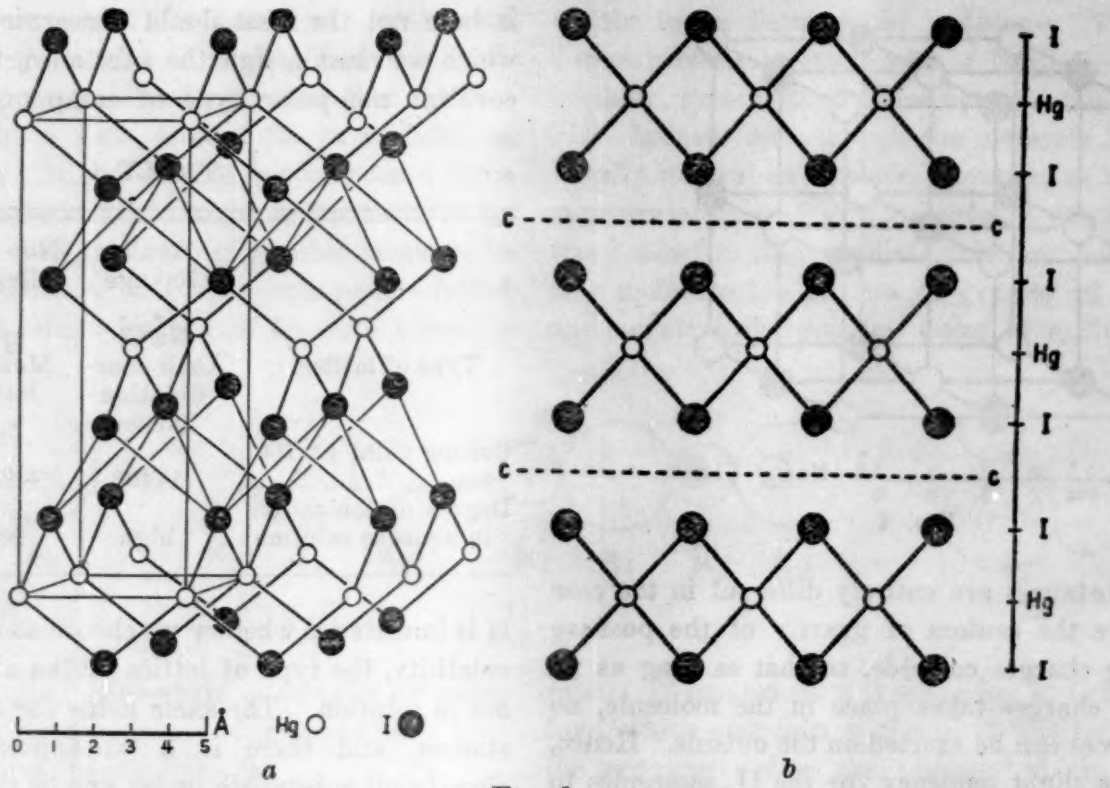


FIG. 6

side, only ions of opposite charge.[3] In the lattice of mercuric iodide, on the other hand, the layer sequence I, Hg, I is followed by I again, the intervals between two neighboring I-layers being greater than that between an Hg- and its neighboring I-layer. Obviously the attractive forces acting between two neighboring, similar layers must be different, and in fact they are weaker than those acting between two unlike layers, just as the forces between the molecules of H_2 are weaker than the forces within H_2. These weaker forces in the lattice cause the cleavability along the planes c-c (Fig. 6b) and, to some extent, the volatility of such crystals.

It is thus evident that none of the three properties mentioned in Table I permits one definitely to decide whether mercuric iodide should be classified as a polar or a non-polar compound. It behaves in an intermediate manner.

The difficulty of classification here encountered is, in the speaker's opinion, inherent in the method of classification itself. The Berzelius theory has failed by reason of its attempt to apply to all substances the same structural principle. It is, moreover, impossible, as we have seen, to understand satisfactorily the behavior of all substances from the view-point of the unitary concept. But classification into two sharply divided groups also is too narrow to explain satisfactorily all the facts. The distinction between the two types of structure mentioned probably will retain its fundamental significance for all time, but it is the speaker's conviction that one should regard them rather as limiting types between which it is possible to have a series of transition forms into which indeed many known substances can be fitted. The limiting case of non-polar linkage is found in the quite symmetrically built molecules: hydrogen, H_2, or chlorine, Cl_2. The other limiting case, the ideal ionic linkage, would be obtained if free positive and negative ions, formed by complete transfer of one or more electrons from one kind of atom to another—as from sodium to chlorine—could be associated with each other as rigid spheres without mutual influence. Real molecules and crystals approximate this limiting case only to a greater or lesser degree, for when two such ions come together a certain change always occurs, a deformation of the ions themselves.

The existence of such deformations can clearly be demonstrated in the case of the formation of mercuric iodide from its ions Hg^{++} and I^-. Aqueous solutions of mercuric nitrate and potassium iodide, containing these ions, are colorless. When these solutions are brought together the ions combine, yielding the intensely red mercuric iodide. This change of color indicates an alteration in the properties of the ions, namely, in the state of their electronic systems. Closer considerations show that in most cases where ions combine to form molecules and crystals it is specially the electronic system of the anion that is changed by the attractive force of the positive charge of the cation. The electronic system of the anion is drawn toward the cation, and thus the transfer of the negative electricity from the one kind of atoms

[3] This holds for any typical ionic lattice, not only for compounds of monovalent elements, such as NaCl (six neighbors each), CsCl (eight neighbors), but also, *e.g.*, for the lattice of fluorite (CaF_2), where each Ca^{++} has eight F^- and each F^- has four Ca^{++} as its neighbors.

to the other during the formation of the ions is reversed to some extent. This deformation (polarization) of the anion indicated in Fig. 7b and c thus leads to a diminution in the polarity of the compound. The degree of this deformation varies greatly in different cases and is, *e.g.*, in Fig. 7, greater in c than in b. It is therefore possible to conceive of an extended series of transition cases between the two limiting types of chemical linkage: one in which the ions are to be considered as rigid spheres which undergo practically no change when combining to form molecules (Fig. 7a), the other in which the electrons of the anions are so strongly drawn toward the cation as to become symmetrically disposed about the two nuclei (Fig. 7d). This latter case would be realized if a negatively charged hydrogen ion, H^-, composed of one proton and two electrons were to combine with a positive hydrogen ion, H^+, consisting of a single proton. This would yield the perfectly symmetrical hydrogen molecule, H_2, in which the two electrons are shared quite equally by both nuclei.

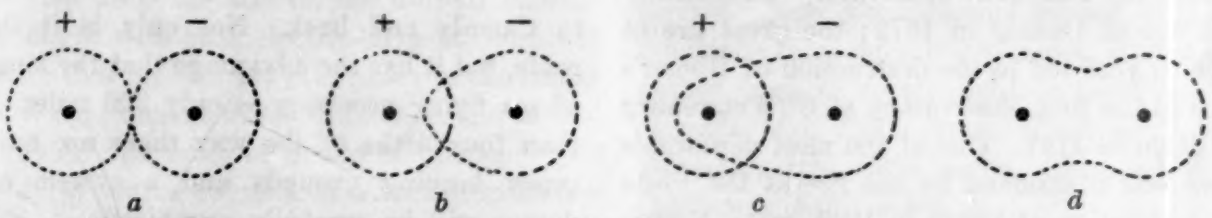


FIG. 7

In general, as was pointed out by the speaker and confirmed by Grimm, extensive experimental material shows that the degree of deformation of the anions increases and the character of the linkage in a molecule or a lattice departs further from the ideal ionic linkage and approaches more closely the non-polar type, the smaller the cation, the higher its charge and the greater the deformability of the anion. Other things remaining the same, in those compounds whose cations lack the character of rare gases the degree of deformation of the anion is greater and the compounds approach more closely the non-polar limit than in the case of those having cations of the rare-gas type. Mercuric iodide stands much farther from the ideal ionic linkage than does sodium chloride, because I^- is much more easily deformable than Cl^-, as refractometric data show, and because Hg^{++} has twice the charge of Na^+. The most important factor in this case is that Na^+ has the structure of neon (eight electrons in the outermost shell, Fig. 1) but Hg^{++} has no rare-gas structure (eighteen outermost electrons). To the intense deformation of the iodine ion by the mercuric ion is due the transition type of mercuric iodide.

Though the classification loses much in simplicity through the presence of these transition types, by taking account of them we attain a single system satisfactory for widely different substances which the dualistic and unitary theories attempted in vain.

I realize that the subject which I have discussed is a difficult one to present to a general audience, and I can only hope that I may have succeeded in giving you some idea of how scientists have attacked this problem of the nature of chemical forces, and of the conclusions which they have reached.

GENERAL REFERENCES

1. G. N. Lewis, Valence and the Structure of Atoms and Molecules, American Chemical Society Monograph, Series, 1923.
2. N. V. Sidgwick, The Electronic Theory of Valency, Oxford, 1927.
3. H. G. Grimm, Atombau und Chemie in Geiger und Scheel Handbuch der Physik., Vol. XXIV (1927).
4. Die Arten chemischer Bindung und der Bau der Atome, Hauptversammlung der Bunsengesellschaft 1928. Also: Zeitschrift für Elektrochemie, *34*, 426–522 (1928).
5. K. Fajans, Zeitschrift für Kristallographie, 61, 18 (1925); *66*, 321 (1928); Zeitschrift für Elektrochemie, *34*, 502 (1928).
6. H. G. Grimm, Zeitschrift für Elektrochemie, *34*, 430 (1928). Naturwissenschaften, *17*, 535, 557 (1929).

SCIENTIFIC EVENTS

HISTORIC APPARATUS[1]

THE Institute of Physics a short time ago appointed a committee to inquire into the possibility of drawing up a catalogue of apparatus which had been used in the course of investigations leading to important discoveries. At the request of the committee the institute is now making a general appeal to all who have charge of historic apparatus. The appeal, which is signed by Dr. W. H. Eccles, Sir F. W. Dyson, Sir W. H. Bragg, Sir C. A. Parsons, Sir J. J. Thomson, Sir R. T. Glazebrook and Sir H. G. Lyons, is made with the object of obtaining information as to the existence of apparatus and the researches it was used in, so that students of the history of science may be able to visit, identify and study it. It is also suggested that the committee could possibly assist the owners, if they so desire, to place the apparatus where it could be per-

[1] From *Nature*.

manently secured to the nation. In such institutions as the Science Museum, the Conservatoire des Arts et Métiers, the Deutsches Museum and the Smithsonian Institution, England, France, Germany and America already possess extensive collections of great value, and there are probably few observatories, laboratories or scientific societies which do not own some historic apparatus, while other instruments are in private hands. Practically every private collection, however, is ultimately dispersed, and the compilation of such a catalogue as that now being formed might lead to the more historic apparatus becoming the nation's property. As with pictures and other works of art, the selective principle should be applied, and a joint committee of the Institute of Physics and kindred societies would be a suitable body to act in an advisory capacity.

In the past, wars, riots and fires have been the cause of the destruction of much valuable apparatus. Gilbert's collection, which he bequeathed to the Royal College of Physicians, was lost in the Great Fire of London; Hevelius lost both observatory and instruments by a fire at Danzig in 1679; the great fire at Copenhagen in 1728 led to the destruction of Römer's telescopes, and the first observatory at St. Petersburg was burnt down in 1747. One of the most deplorable of all losses was occasioned by the fire at the Volta Centenary Exhibition at Como in 1900, when Volta's original piles and cells, etc., were lost. Wars have been no less destructive than fires. The manuscripts of Thomas Harriott, astronomer and mathematician, disappeared during the Civil War; Gregory Saint-Vincent, the seventeenth century geometer, lost all in the siege of Prague; Chladni lost some of his acoustical apparatus during the Napoleonic Wars, while Regnault, after the occupation of Paris by the Germans, returned to his laboratory at Sèvres to find his standard apparatus and the results of his great researches on the expansion of gases ruined. The destruction of Priestley's library and apparatus occurred during the Birmingham Riots of 1791. How important instruments may disappear unrecorded is shown by the case of Sturgeon's electrical apparatus. In 1825 the Royal Society of Arts recorded the award of a medal and thirty guineas to Sturgeon for the gift of his electromagnetic apparatus, but this, including the first electromagnet ever made, has unfortunately long since disappeared. Such, it may be hoped, will not happen to any important collection in the future, and we feel that the Institute of Physics is doing a public service in obtaining records which should go far to prevent such losses from happening.

BRITISH AIR ROUTE TO THE ARCTIC REGIONS

WITH the object of establishing an Arctic air route from Great Britain to Canada an expedition of British scientific men will, according to a wireless despatch to the New York *Times*, make the journey in Sir Ernest Shackleton's historic ship "Quest." A group including surveyors, airmen and meteorologists sailed on July 3 for the Faroe Islands, Iceland and Greenland, where they will stay an entire year exploring a route to the North American continent. The Canadian government has shown great interest in the proposal and will soon undertake a survey of the Canadian end of the proposed route from Winnipeg up through Hudson Bay and Baffinland.

The expedition, which is being sent under the auspices of the Royal Geographical Society, will be equipped for a thorough meteorological and geographical survey of Greenland. Airplanes, fast motorboats and dog-teams for scouting trips will all be at the disposal of the expedition on the shores of Iceland and Greenland and on the vast ice-cap of the interior.

As the route has been surveyed an experimental flight will be made over the entire route from England to Canada and back. Not only is it the shortest route, but it has the advantage that the longest stretch of sea flying necessary is only 300 miles. For more than four fifths of the way there are natural emergency landing grounds and a system of gasoline dumps will be carefully organized.

The whole center of Greenland is a vast ice plateau about 500 miles across on a line between Iceland and Baffinland, and rising to 8,000 feet above sea-level. This plateau has been crossed only twice anywhere near its center, and all crossings have been made in summer.

The expedition will establish a base camp on the southeastern coast of Greenland and a station on top of the ice-cap. Meteorologists will stay on the ice-cap a whole year.

From this central base dog-sled expeditions will set out on journeys into the far north of Greenland and down to the south coast. The coastal base camp will be near the Eskimo settlement of Angmagsalik, about forty miles inshore. The central base will be about 150 miles inland on the highest part of the great frozen plateau.

The Prince of Wales has consented to be honorary president of the committee in charge. The leader of the expedition will be H. George Watkins, who led two previous Arctic expeditions. His companions will be Augustine Courtauld, explorer and surveyor; James M. Scott, surveyor and dog-driver; Flight Lieutenant N. Hughes d'Aets, pilot and meteorologist; Captain Percy Lemon, wireless operator; Lawrence R. Wager, geologist; Andrew Stephenson, chief surveyor; John Rymill, surveyor; Fred S. Chapman, ornithologist and ski expert; Quintin Riley, meteor-

ologist; Wilfred E. Hampton, engineer, and Lieutenant Martin Lindsay, surveyor.

The whole project has the warmest assistance of the British and Canadian government departments. The British Air Ministry has lent Lieutenant d'Aets, who is a Royal Air Force officer, while the War Office has lent Captain Lemon, one of its most expert wireless operators. Many government departments are helping with loans of instruments, while the Vickers Aviation Company has offered a Vellore plane for experimental flights and the Royal Geographical Society has helped technically and financially.

A PRIMARY STANDARD OF LIGHT

THE Bureau of Standards has issued the following statement in regard to its work on a primary standard of light: Up to the present time no satisfactory standard has been available. In this country the unit of light (the candle) has been maintained by a group of 45 carbon-filament electric lamps, to which have been assigned definite ratings when burned under specified conditions. To keep the size of the unit of candlepower unchanged with such electric-lamp standards it was necessary that no changes take place in the lamps themselves, a requirement which can not be met indefinitely by any electric lamp or group of lamps.

The new light source consists of a hollow inclosure of fused thoria immersed in a bath of pure freezing platinum. It is reproducible in that it can be set up anew at any time and does not depend upon the unchanging character of any particular pieces of material. It depends only upon the constancy of a natural phenomenon, namely, the fact that pure platinum will always freeze at the same temperature. The light emitted each time the source has been set up anew has been found to be the same, as compared with the bureau's carbon electric lamp standards, within 1 part in 1,000. This is about the limit of accuracy attainable in photometry.

The old electric lamp standards were irreplaceable and their loss or a serious change in their properties, such as must eventually occur, would in the past have been nothing less than a catastrophe. If, however, such a loss occurred now, the bureau could replace these lamps without the assistance of outside laboratories by rating a new set of lamps in terms of the light emitted by the platinum standard. The relation of this light to the present unit of candlepower has been accurately established as one candle for each 1,700 square millimeters of opening.

It happens, fortunately, that the color of the light emitted by the new standard is practically identical with that emitted by the old standard. It is hoped that before very long the new light source will be recognized generally and adopted as an international standard.

REFORESTATION DURING 1929

FOREST planting by all the principal agencies engaged in the work of reforestation in the United States last year restored to tree growth a total of 111,175 acres, as shown by records just completed by the Forest Service.

The total acreage set out in young forest trees in 1929 included 107,557 acres in the continental United States, 2,084 acres in Hawaii and 1,534 acres in Porto Rico. Reforestation activities included the planting of 31,430 acres by 21 states and two territories, 5,920 acres by municipalities, 25,088 acres by industrial organizations, 539 acres by schools and colleges, and 1,516 acres by other organizations. Plantings by farmers for the extension or improvement of farm woodlots and windbreaks amounted to 24,825 acres, and plantings by other individuals, 6,650 acres. The U. S. Forest Service planted 18,027 acres of land on national forests in 1929.

Michigan, with 27,820 acres restored to tree growth, led the states last year in total acreage planted to forests. New York ranked second with 21,135, and Louisiana third with 10,583 acres. Other states which ranked high in forest-planting activities were Pennsylvania with 6,318 acres; Washington, 4,400 acres; Massachusetts, 3,938 acres; Ohio, 3,428 acres, and California, 3,023 acres.

Industrial forest plantings in 1929 included 10,060 acres planted by pulp and paper companies, 8,732 acres by lumber companies, 3,189 acres by water and power companies, 1,561 acres by mining companies, 100 acres by railroad companies and 1,446 acres by other industrial organizations.

To the end of the calendar year 1929, the cumulative total of all forest planting in the United States of which the Forest Service has record was 1,653,308 acres. This included 274,385 acres of national forest land planted by the federal government, 200,553 acres by states, 46,282 acres by municipalities, 193,262 acres by industrial organizations, 16,335 acres by other organizations, 5,215 by schools and colleges and 917,276 acres by farmers and other individuals. In cumulative acreage planted, Iowa led with 242,260 acres, Nebraska was second with 219,088 acres, Kansas third with 201,190 acres and New York fourth with 183,369 acres.

YALE UNIVERSITY AND THE BERNICE P. BISHOP MUSEUM

YALE UNIVERSITY and the Bishop Museum, Honolulu, have entered into a new agreement which will bring about a closer affiliation of the two institutions.

The research program of the museum, the only institution which devotes its energies solely to a study of the Pacific area, will be integrated with the activities of those departments of the Yale Graduate School

whose work bears on the scientific problems of the Pacific. This is expected to improve the work of the museum by bringing it under the supervision of the scientific men at Yale, and will strengthen the educational program of the Graduate School by making available for purposes of instruction and research materials obtained by the museum through its field study of Pacific problems.

To give effect to this purpose it has been agreed that the director of the museum shall be a member of the faculty of the Graduate School assigned to duty in Hawaii. The present director is Professor Herbert E. Gregory. Each year the museum will send to Yale a visiting professor to give instruction and direct research in the problems of the Pacific area. A standing committee of the Graduate School will undertake to supervise the research program of the museum, to correlate this with the activities of the scientific departments at Yale, and to plan and direct the work of the visiting professor. To stimulate among graduate students interest in the problems of the Pacific, fellowships of large stipend will be awarded annually to students who are qualified to engage in research under the direction of the museum.

President Angell points out that "the research activities of the Bishop Museum in the natural and social sciences have been of the highest scientific value. By reason of its central position it is strategically placed to study the cultural, geological and zoological problems of the Pacific area. This it does through scientific expeditions to the islands and bordering mainlands which gather data of great importance to the anthropologist, the social scientist and the scholars interested in different branches of the natural sciences. Hereafter these activities will be a part of the general program of the Yale Graduate School."

The Bernice P. Bishop Museum has given much attention to the native races of the Pacific. The studies entered upon by Yale and the museum have led to the discovery of ruins of great antiquity in the Mariana islands, between Hawaii and the Philippines, which indicate a vanished civilization in the Pacific comparable to that of the ancient mainland. These ruins are expected to throw light on the origin and immigration of the Pacific people. By some routes in the distant past these people left the Asiatic continent and spread over an area 8,000 miles long and 6,000 miles wide. To trace these routes and to find out who these early people were is one of the problems which the investigators at Yale and the museum are trying to solve. It was in investigating a probable route from Mongolia through Japan to the Marianas and thence to Samoa and Hawaii that these significant ruins were discovered.

FURTHER ACADEMIC DISMISSALS IN MISSISSIPPI

There were recorded in the issue of Science for July 18 the professors dismissed from the University of Mississippi.

On July 5, 1930, the Board of Trustees of the University and Colleges of Mississippi, without warning, giving of reasons, or preferring charges of any sort, dismissed the members of the faculty of the Mississippi College of Agriculture and the Mechanic Arts, as listed below. It is said that the board plans to take similar action at the Experiment Station.

Charles F. Briscoe, professor of bacteriology.
F.-J. Weddell, professor of English.
F. D. Mellen, professor of public discourse.
H. W. Moody, dean of the School of Engineering and professor of physics.
M. L. Freeman, professor of drawing.
J. C. C. Price, professor of horticulture.
Hal Fox, professor of mathematics.
J. R. Gulledge, librarian.
F. H. Herzer, associate professor of dairying.
A. G. Burg, associate professor of agronomy.
G. F. Barnes, associate professor of physics.
C. B. Cain, associate professor of veterinary medicine.
R. G. Dauber, assistant professor of physical education.
L. S. Lundy, assistant professor of mathematics.
G. B. Drummond, assistant professor of mathematics.
J. R. Ricks, director of experiment stations.
R. S. Wilson, director of extension.
J. W. Willis, assistant director of extension.

The president, B. M. Walker, and the vice-president, J. C. Herbert, had been displaced at an earlier meeting. Many secretaries, stenographers and others were among those dismissed.

SCIENTIFIC NOTES AND NEWS

Dr. Stephen Moulton Babcock, emeritus professor of agriculture and chemistry at the University of Wisconsin, the inventor in 1890 of the Babcock milk test which revolutionized the dairy industry, is to receive the Capper award of $5,000 and a gold medal at the annual meeting of the American Country Life Association, to be held at the University of Wisconsin from October 7 to 10.

The University of Freiburg has conferred the honorary degree of doctor of natural philosophy upon Dr. F. W. Aston, of Cambridge, in recognition of his work on isotopes and other subjects.

THE honorary degree of Sc.D. was conferred on July 4 by the University of Dublin on Sir John Hopwood Jeans, secretary of the Royal Society.

IT is stated in *Nature* that in connection with the International Botanical Congress, which is to be held in Cambridge in August, it has been decided to confer honorary degrees on the following: John-Isaac Briquet, director of the Conservatory and Botanic Garden, Geneva; Pierre Augustin Clément Dangeard, professor of botany at the Sorbonne; Friedrich Ludwig Emil Diels, professor at the University of Berlin and director-general of the Botanic Garden and Museum at Berlin-Dahlem; Thore Gustaf Halle, professor and keeper of the Paleobotanical Department of the Swedish State Museum of Natural History, Stockholm; Lewis Ralph Jones, professor of plant pathology at the University of Wisconsin; Carl Joseph Schröter, emeritus professor of botany at the Technical University of Zurich, and Friedrich August Ferdinand Christian Went, professor of botany and director of the Botanic Garden and Laboratory of the University of Utrecht.

DR. LUDWIG A. THIELE, chemical engineer, Gowanda, N. Y., was recently awarded the degree of doctor of science by the University of Brussels.

THE Louisiana State Medical Society gave a dinner in New Orleans on July 12, in honor of Senator Joseph E. Ransdell, author of the bill to establish a National Institute of Health. The speakers were Dr. Joseph C. Bloodgood, of the Johns Hopkins University; Surgeon General Hugh S. Cumming, Washington, D. C.; Dr. Edward Starr Judd, of the Mayo Clinic; Dr. Charles H. Herty, of the Chemical Foundation, New York, and Dr. Rudolph Matas, of the School of Medicine of Tulane University.

THE new department of medical and surgical research, instituted in the Ohio State University College of Medicine, Columbus, will soon begin work. Dr. Charles A. Doan, the director, has recently arrived from the Rockefeller Institute, New York. Dr. Bruce K. Wiseman will be the assistant director. The department will be inaugurated in Hamilton Hall, where it will have access to the University Hospital.

DR. WILLIAM THORNTON READ, formerly head of the department of chemistry at the Texas Technological College, has been appointed dean of the newly organized School of Chemistry at Rutgers University. *Industrial and Engineering Chemistry* states that his work at Rutgers will include not only the training of Rutgers students of chemistry, but also the organizing of an extension program of instruction for chemists, ranging from the humblest plant man to the highly trained technical graduate.

J. E. MILLS, immediate past chairman of the division of chemistry and chemical technology of the National Research Council, formerly chief chemist of the Chemical Warfare Service, has accepted appointment as professor of chemistry in the University of South Carolina.

DR. LOUIS N. KATZ, who recently resigned his position as assistant professor of physiology in the School of Medicine of Western Reserve University, has accepted the post of physiologist and director of cardiovascular research at the Michael Reese Hospital, Chicago, and has been appointed assistant professor of physiology at the University of Chicago.

DR. H. M. LAKE is leaving the University of Texas to become instructor in psychology at Colgate University, where he will teach applied psychology.

ACCORDING to *Nature* new professors have been appointed at the University of London to chairs as follows: *Bacteriology* (University College Hospital Medical School), Mr. C. Cyril Okell; *Chemistry* (University College), Professor C. K. Ingold, now professor of organic chemistry in the University of Leeds; *Geography* (Birkbeck College), Miss E. G. R. Taylor; *Physics* (Imperial College—Royal College of Science), Professor G. P. Thomson, now professor of natural philosophy in the University of Aberdeen.

DR. LEE DE FOREST, director of the Institute of Radio Engineers, is preparing to move his entire organization to Hollywood, where he will engage in intensive work on apparatus used in motion pictures, television and ultra short-wave radio.

VICTOR T. STRINGFIELD and Charles V. Theis have been appointed assistant geologists in the Water Resources Branch of the U. S. Geological Survey.

DR. FRANCIS CARTER WOOD, director of the Crocker Cancer Research Institute of Columbia University, sailed on July 23 to attend the International Congress of Experimental Cytology at Amsterdam.

DR. D. T. MACDOUGAL, of the Carnegie Institution of Washington, has been appointed as representative of the Torrey Botanical Club to the International Conference on Plant Nomenclature.

THE New York Botanical Garden will be represented in the fifth International Botanical Congress at Cambridge, England, by Director E. D. Merrill, Dr. J. H. Barnhart, Dr. B. O. Dodge, Dr. H. A. Gleason and Dr. A. B. Stout. Messrs. Dodge, Gleason, Stout and Merrill have already left for England and Dr. Barnhart will leave early in August. They will remain in Europe until late in the fall as they are planning research work at Kew and other European institutions. Dr. Elmer D. Merrill is one

of the vice-presidents of the congress and also a vice-president of the section on taxonomy.

DR. M. O. MALTE, chief botanist of the national herbarium of the National Museum Branch of the Dominion Department of Mines, Ottawa, sailed from Montreal on July 29, to attend the International Botanical Congress. Before and after the congress Dr. Malte expected to visit the British Museum and the Kew Botanical Gardens to study collections of Arctic flora. He will also visit the Botanical Museum at Copenhagen for the same purpose.

DR. JESSE MORE GREENMAN sailed for Europe on July 30, as the delegate of the Missouri Botanical Garden to the Botanical Congress. Afterwards he will visit the great botanical centers of London, Brussels, Paris, Berlin, Vienna, Munich and Geneva for the study of types of American plants in European herbaria.

GUSTAVUS J. ESSELEN has been appointed by the National Research Council as the representative of the division of chemistry and chemical technology to attend the tenth Congress of Industrial Chemistry to be held at Liége, from September 7 to 13.

PROFESSOR CARL R. MOORE, of the department of zoology at the University of Chicago, and Professors R. G. Gustavson, F. C. Koch and Mr. T. F. Gallagher, of the department of physiological chemistry, are attending the second International Congress for Sex Research in London, which will be held from August 3 to 9.

DR. JOSEPH F. ROCK, working under the auspices of Harvard University and the U. S. Department of Agriculture, arrived at Hongkong on July 22, *en route* to the city of Lichiang where he plans to work for five years among the Nashi tribe. Dr. Rock also plans to conduct a study of medical and economic plants of the region for introduction into the United States under the supervision of the Department of Agriculture.

HAVING completed two months' lecturing and studying at the Institute of Biology at Tohoku Imperial University, Sendai, Professor Charles A. Kofoid, of the University of California, will spend the rest of his time in Japan at the institute's marine station at Asamushi, giving graduate instruction and carrying on research. In August he will read a paper before the Japanese Zoological Society on "The Neuromotor System of a Protozoa."

THE one hundred and sixty-fifth anniversary of the founding of the University of Pennsylvania's School of Medicine, the oldest on the American continent, will be celebrated on October 10 and 11. There will be a university convocation, at which honorary degrees will be conferred upon a number of men who are internationally known in the field of medicine. Included among these will be Sir Walter Fletcher, of London, executive secretary of the Research Council of Great Britain, and Professor A. V. Hill, of the institute of physiology, University College, London. Sir Walter and Professor Hill will deliver addresses during the celebration. In the afternoon there will be a series of meetings and clinics. On the following day the tentative program calls for an inspection of new buildings in the medical group. Among the recent developments to which attention will be called are the erection of the Martin Maloney Memorial Medical Clinic Building, the establishment of the Eldridge R. Johnson Foundation for Research in Medical Physics, the Edward B. Robinette Foundation for the study, treatment and prevention of diseases of the heart and circulatory system, and the reestablishment of the Pepper Laboratory for Clinical Medicine and of the John H. Musser Department of Research Medicine in the new Maloney Clinic Building.

THE formal opening took place on June 30 of the new animal breeding research department of Edinburgh University. An address, in which he made a defense of vivisection, was given by Professor Sir Edward Sharpey-Schafer. Occasion was also taken to confer the honorary degree of LL.D. upon Mr. T. B. Macaulay, president of the Sun Life Assurance Company of Canada, who some time ago endowed a lectureship in the department for the encouragement of research directed towards human physiological problems.

THE degree of bachelor of science has been abolished by the board of trustees of Princeton University. Beginning with the class of 1934 all graduates, except those in the engineering school, will receive the bachelor of arts degree.

MR. CYRUS H. K. CURTIS, of Philadelphia, has given $500,000 to Bowdoin College and $100,000 to the Maine General Hospital at Portland.

AT the recent session of the board of regents of the University of Texas, plans and specifications were authorized for the enlargement of the present laboratory building of the state medical college. The cost will be approximately $350,000.

MR. EDWARD S. HARKNESS, of New York, is reported to have offered £2,000,000 to endow social and educational work in Great Britain.

APPROPRIATIONS amounting to $410,008 were made available to the University of Wisconsin by recent action of the emergency state board, releasing funds

to that amount to the board of university regents. The largest single item is $169,508 for the construction and equipment of an agronomy wing to the horticultural building. The next largest is $100,000 for the construction of an addition to the present student infirmary. Other items include $27,500 for the purchase and installation of safety devices throughout a number of university buildings; $22,000 for moving equipment from its present location to the new mechanical engineering building in process of erection at Camp Randall; $25,000 for an electric distribution system; $15,000 for a water line to the pump house; $16,000 for the purchase of real estate, and $35,000 for the construction and equipment of a new building for animal research.

ACCORDING to the terms of a recent appropriation by Congress, the United States Department of Agriculture will establish a new field laboratory on the Pacific coast to study problems of bee-keeping in that region. The site of the new laboratory has not been selected, but a location in which most of the problems to be studied will apply is being sought. In addition to the bee-culture laboratory near Washington, D. C., the department now operates field laboratories at Laramie, Wyo., and Baton Rouge, La. The bill provides $15,000 for bee-culture investigations on the Pacific coast with the new field laboratory as headquarters.

APPROXIMATELY 14,144 acres of land were added to the Rocky Mountain National Park, Colorado, by proclamation of President Hoover dated June 25, upon recommendation of the Secretaries of the Interior and Agriculture. Authority for the addition of the land was contained in the act of Congress approved on June 21. The new addition adds to the park the headwaters of the Colorado in the vicinity of the Never Summer Mountains, picturesquely so-called by the Indians because of the everlasting snows that spatter their summits. This is a magnificently scenic area. In this region the Continental Divide makes a U-shaped loop, forming a broad valley through which the Colorado River winds. About one third of this basin was included in the national park, the remaining portion being in the adjoining national forest. Under the presidential proclamation it is all included within the park. In addition to its scenic value, the new area is of geologic interest and constitutes a natural unit of the park. Through it will be constructed a portion of the new Trail Ridge road, which, when completed, will be the highest continuous road in North America. At one point it will reach an altitude of 12,120 feet, and 9 miles of its total length of 28 miles will be located above timberline.

THE French Minister of Public Instruction has, according to the *Journal* of the American Medical Association, appointed a commission to draw up a bill to provide that, out of the profits of commercial establishments exploiting a scientific discovery, a certain proportion shall go to the benefit of the scientists who made the discovery. Such a law has been demanded for many years, and the Commission Internationale de Coopération Intellectuelle has already discussed the subject at length. It has conceded, in principle, that it is just to recognize the existence of certain rights of ownership in scientific inventions and discoveries, just as the rights of ownership in artistic productions are recognized. A French law, which dates back three years, accords to the author of a painting and to his descendants for a period of fifty years after his death a *droit de suite,* that is to say, a percentage of the price paid for the picture every time it is resold. It has been considered unjust that a work of art for which the artist who creates it usually receives a low price should enrich several merchants by successive sales and speculations whereas the artist and his family remain in misery. It is now regarded as no more than just to apply the same principle to the author of a scientific discovery which, even though it can not be patented, will, by exploitation, enrich a number of industrialists and merchants. Laboratory workers receive modest salaries in the faculties or the scientific institutes, but their research becomes for others a source of wealth in which they have no part. A small percentage will therefore be figured on the profits of industrialists exploiting a discovery that is not entitled to a regular patent, and the sums thus collected will be placed in a special fund destined to furnish indemnification to the scientists who are the authors of exploited discoveries. This fund will be a *caisse commune,* which can be used likewise to indemnify other scientists, authors of discoveries in pure science and not capable of exploitation. The fund may be used also for the creation of research laboratories and experimental hospitals. A special commission composed of scientific men acting under the ministry of public instruction and administer the fund and will see to its judicious distribution.

DISCUSSION

CONIFER INFLORESCENCE

STROBILAR structure and origin form a much more enigmatic subject than can be readily pictured. At once an utter difficulty of definition and the tangle of inequal terms is encountered. The relation between the cone and flower is tied up with the inflorescence. Inadvertently the student thinks that a flower has no semblance to the unit of structure in a cone

and that the cones of pines must be far simpler and older than any flowers, both ideas being the exact reverse of the truth. Giantism, reduction and elimination, even more than progressive changes, obscure the primitive structures, while the view that the higher seed plants arose somewhere near their first observed occurrence in geologic time has so dominated botanical thought that views of descent have been much too restricted to reach fuller clarity.

Within the past few years, however, much real progress has been made in the study of the ancient history of the conifers. Both Araucaria and the pines are traced back to the Carboniferous. Older cones are more complex and leafy; single scales fewer, and groups of seed scales suggesting shoots more in evidence. No less, unity in the entire Conifer-Araucaria phylum as it appears in the flora of to-day is very certain. In the fossil genus Pararaucaria accompanying the Araucaria cone series from the Cerro Cuadrado, Patagonia, bract and scale are both prominent, while the seeds are curtained by the tissues of the scale. Outer appearance was not markedly different from Picea or Larix, except in the much larger bract, although, as if nature intended to prove the point further from the fossil side, the scale, as normally one-seeded as in Araucaria, is rarely seen to be both one and two seeded in one and the same cone.

The shoot or inflorescence theory of the cone advanced at various times best seems to fit the increasing evidence. It is recalled that abnormal cones of Picea with leafy axes in the bract axils seemed to indicate the seed scale to be the remnant of a shoot. The apposed view was that the staminate and ovulate cones are strictly homologous, with the bract itself a sporophyll and the scale really an outgrowth from it bearing the seeds. But this latter view seems to fail, or at least can only suggest plants very much simpler than any conifers and living far back in time, plants embryologically simple as in early Cordaites or in pro-Conifers. Much depends on the interpretation of the Gnetaleans. Did they all once have complete flowers? At least the flowering gymnosperms were a reality and can only be thought of as numerous and varied in Permo-Carboniferous and later times. Leaving embryogeny somewhat aside or as a thing in itself progressive, conifers might be as much the descendants of angiosperms as the reverse. That is, conifers are now specialized utterly in flower and foliage, though ancient in wood structure. Conversely, the angiosperms are still plastic in their flowers, but absolutely advanced in embryogeny, leaf and wood. Casuarina is an angiosperm which wanted to be a conifer, but started too late.

It is expected shortly to illustrate some of these points at length and adequately in an account of the Field Museum collections from the Cerro Cuadrado. In searching for collateral illustration use has been made of a hasty method of cone sectioning and illustration which may have escaped note by many teachers of botany. The great pine cones when thoroughly dry may with care be close wrapped in several ways to prevent breaking of the scales, and then set in the heavy oak jaws of an old-fashioned carpenter's vise and sawn through on the lines needed for all the desirable sections. A narrow, fine-toothed orchardist's pruning saw is about the best for the purpose. After sawing out the various sections it is, however, quite necessary to have at hand polishing laps of the lesser sizes run at rather low rates of speed to avoid breaking the projecting scales. Then instead of the felts used in ordinary petrified wood polishing, sand paper of several grades of fineness may be used to bring the surfaces of the sections down to the needed smoothness cleared of saw cuts. The sections need no staining and no treatment. The natural colors leave all features of the woody cylinder and bundle patterns in bold outline. The color values lend themselves to photography. By first loosing and setting aside the seeds these may then be replaced in the finished transverse section. The great cones of Coulter's pine, the Sabine pine and the knobcone and sugar pine so sectioned afford remarkable material for classroom use in botany. No one who has seen such sections will ever again be in doubt about the organization of the cone, the features of the woody cylinder, the origin of the bract and scale supply and their features as they traverse the cortical parenchyma to divide up for the later course in bract and scale. Even the smaller cones can be similarly seen. The impression gained will be one of a remarkable unity in the general features of seed cones throughout the conifers, just as emphasized by Eames, studying Agathis several years ago, and by Worsdell.

Of course the student ought to hold in mind a variation of type which runs all the way from such an open lax cone as that of *Podocarpus andinus* to the giant close-set woody types, or yet includes cones, inflorescences, reduced to but a single seed as in the yew, where the modified seed scale is quite surrounded by bracts. He ought to recall that the angiosperms are a unit in which the flower was present in very ancient days, and that the ament of the poplar and the willow results from inequal reduction of those primitive flowers to forms analogous to coniferous fertile shoots. He ought to see that the cycadeous strobilus is the remote prototype of the magnolia seed cone; that there must be hidden in the older rocks

an amphisporangiate strobilus, either simple or complex. That strobilus is in a measure visualized in Cycadeoidea. Maybe it is seen in Tumboa. In any case it was a forerunner of flower and cone.

G. R. WIELAND

YALE UNIVERSITY

THE SPECTRA OF GASES LIGHTED WITH STRONG ELECTRICAL DISCHARGES

THE spectrum of a gas is known to vary with the pressure and the type of electrical excitation. Experiments were undertaken to find out what the spectrum of the gas is like when very strong discharges are used. A small discharge tube containing the gas at pressures up to several cms of mercury was arranged to be excited either in the usual way by the discharge of a transformer, or by a small 0.002 microfarad condenser, or by the violent discharges of a 1 microfarad condenser charged to 15,000 volts. The discharge of a 1 microfarad condenser at this voltage is quite an energetic affair; it produces a blinding flash of light and a pulse of sound like a gunshot. With hydrogen in the tube the Balmer lines widened with increasing strength of the discharge, the higher members of the series disappeared and the continuous spectrum became more intense, until with the 1 microfarad condenser discharges there were no Balmer lines left at all, only the continuous spectrum and some absorption lines due to aluminum from the electrodes, etc. Helium, oxygen and nitrogen exhibited similar changes, *i.e.*, with increasing intensity of the discharge in helium the lines gave way to a continuous spectrum, and in oxygen and nitrogen the molecular bands gave way to spark lines and these in turn to a continuous spectrum. The continuous spectra from all the gases were closely alike. The intensity distribution across the continuous spectrum was rather even and probably not that of a black body.

The result of the experiments was in some respects a surprise, although to be sure as the experiments progressed one could see in what direction they were headed. That certain lines would widen or disappear in the intense discharges was to be expected, but to find all the lines wiped out and their places taken by a smooth continuous spectrum was hardly anticipated. It seems that the external characteristics of the atoms were pretty well effaced. One may imagine that the conditions approached those in the interior of a star.

E. O. HULBURT

NAVAL RESEARCH LABORATORY

SCIENTIFIC MINUTE MEN IN ANTHROPOLOGY AND ARCHEOLOGY

IN cooperation with the Division of Anthropology and Psychology of the National Research Council, Science Service has arranged a plan by which competent and accurate reports of rumored discoveries relating to anthropology and archeology may be obtained for prompt publication in the press. The committee, appointed by the Division of Anthropology and Psychology, National Research Council, is as follows: Dr. Roland B. Dixon, Harvard University, Cambridge, Massachusetts; Dr. A. L. Kroeber, University of California, Berkeley, California; Dr. Leslie Spier, University of Washington, Seattle, Washington, and Mr. Neil M. Judd, chairman of the committee, U. S. National Museum, Washington, D. C. Dr. Fay-Cooper Cole, chairman of the division, has been helpful in formulating the plan.

The plan, briefly, is this. Selected anthropologists, geologists and paleontologists situated in geographically strategic localities are commissioned special correspondents of Science Service and authorized to visit and investigate any reported discoveries in their vicinity which may appear important or likely to receive wide publicity. Science Service guarantees to defray expenses up to $50.00; more than this, by prior agreement. Specific authorization is not required but the collaborator uses judgment in determining what needs investigation and, to avoid duplication of effort, first ascertains that others near by are not also starting out on the same report.

Before starting on any specific investigation, each investigator states what is known of the reported discovery, his personal plans, telegraphic address, etc., in a concise telegram sent press rate collect to Science Service, Washington, D. C. He does not wait for an answer but proceeds immediately with the investigation. Upon arrival at the site, the results of preliminary investigation are telegraphed to Science Service. Details and photographs are sent as soon as possible by mail.

Investigations are restricted to reported discoveries that seem likely to be of real importance or that seem likely to create considerable publicity. Science Service, supplying science news to a fifth of the newspaper reading public in America, is desirous through this plan to distribute accurate and prompt news of all important archeological and anthropological investigations before exaggerated and misleading statements are circulated.

The investigator arranges with his institution to coordinate his efforts under this cooperative plan with his activities on behalf of his institution. The scientific results of any investigation may be published as the scientist sees fit, but news reports and public statements, in consideration of the participation of Science Service, are distributed exclusively through Science Service.

Sixty-six archeologists and anthropologists located

in strategic centers in the United States and Canada are now designated as Science Service minute men in archeology and anthropology under this plan.

Two investigations under the plan have already been made. Drs. Alfred S. Romer and Wilton M. Krogman, of the University of Chicago, and Russel T. Neville, of Kewaunee, Illinois, visited a cave in Leasburg, Missouri, where human remains were reported to be found and they determined that the bones were those of bears. When a report of the discovery of "prehistoric giants in West Virginia" gained wide currency, D. T. Stewart, of the U. S. National Museum, visited the site of the bone discoveries near Morgansville, West Virginia, and found that the bones were probably those of normal-sized Indians. In cooperation with Professor Ernest R. Sutton, of Salem College, he excavated further in the mounds and inspired local amateur archeologists to more effective research in a territory which is largely an archeological no-man's-land.

In addition to the news reports of the investigations which will find publication in newspapers and magazines through the usual channels of Science Service, more detailed announcements of these researches will be prepared and sent upon request to those who express an interest.

WATSON DAVIS

SCIENCE SERVICE

TWO UNUSUAL FLOCKS OF SWANS

IN recent years the appearance of the whistling swan, *Cygnus columbianus* (Ord), in large numbers is so unusual an event that the occurrence of a flock of fifty is a matter of note among ornithologists. Forbush,[1] in reference to this bird states, "In New England we rarely see or hear them now. Once they were abundant in migration along our coasts and many a lake. . . . Now the few that pass over or through our territory fly so high that they are rarely noticed, or they keep well out on wide water during daylight." Barrows, in his "Michigan Bird Life," says, "Single birds or small squads occasionally alight during bad weather in ponds and streams in various parts of the state," and quoting Butler,[2] "'Formerly when these birds were more abundant they migrated in flocks of twenty or thirty, and sometimes as many as fifty high in the air.'" In Wisconsin, Schorger has just issued a report on the birds of Dane County. The territory covered by the report includes a number of lakes which are much frequented by waterfowl during the season of migration. The observations recorded extend over a period of twenty years, but swans were seen in only three of these, and on only seven different occasions. The largest flock observed contained forty individuals; the others less than eight each.

All the authorities cited lay special emphasis on the rarity of the bird. The appearance this spring of a large number of swans on Lake Winnebago seems therefore to merit notice.

About the first of April swans were reported to be at the northwest extremity of the lake, near Neenah. The writer visited the locality on April 5. The birds were shy and remained well off shore, but a count was possible through glasses. The number of individuals was ascertained to be two hundred.

On the same day a larger flock was reported from a location twelve miles south near Oshkosh. On April 7, after photographing the Neenah flock, which had apparently diminished little if at all in numbers, the writer drove to the Oshkosh shore. The flock here was stretched out in a great band approximately a mile in length and more or less paralleling the shore line. So close in was this band that the red beaks of the younger birds showed prominently and even the yellow spots on the beaks of older birds could be distinctly seen through six-power glasses. The individual birds were counted and found to number one thousand and seven.

A third flock, of small size, was reported to be at the southern end of the lake but this report has not, up to date, been verified. We have, however, knowledge of approximately twelve hundred swans on the lake at one time.

Accounts obtained from residents along the lake shores varied so widely that it was out of the question to determine just when and in what numbers the birds had arrived. But it is certain that these flocks are not remaining intact in their migratory movements. The smaller group in disappearing during the night of April 8 left three of its number on the lake. The larger flock shrank to one hundred and seventeen individuals between the eighth and noon on the tenth. All afternoon, on the latter date, swans in groups of from three to seven individuals left the feeding grounds until at evening only sixty remained. Three days later these sixty stragglers were still on the lake.

NELL A. ROGERS

APPLETON, WISCONSIN

CURIOSITIES OF SCIENTIFIC NAMES

I AM very much interested in Dr. Howard's notes, page 330 of SCIENCE for October 4, entitled "Odd Stories about Scientific Names." Some enterprising scientist could compile a book full of such stories and

[1] Edward Howe Forbush, "Birds of Massachusetts and Other New England States," p. 304.

[2] Amos W. Butler, "Notes on Indiana Birds," *Proc. Ind. Acad. Sci.*, 1891.

it would make good reading. Is it not an error to perpetuate errors in scientific names? Only yesterday my attention was called to the following: A deer was found in Big Pine Key in South Florida different from the common deer (*Odocoileus virginianus*). Barbour and Allen gave it the subspecific name *clavium*, meaning "of the Keys." Unless my Latin is very much at fault, this word refers to the kind of keys that you lock doors with, and is no way related to the word quay, cay or key—terms applied to little islands on the Florida coast and in the West Indies. The word "keyensis" or "cayensis" should be used.

There are many like the following.

Our Fiddle-wood belongs to the genus Citharexylon, which means fiddle or violin wood. The woods of this genus are usually extremely heavy and hard and probably have never been used in the manufacture of fiddles. The word fiddle in this instance is probably a corruption of the French word *fidèle*, meaning strong, true and trustworthy.

We should be all the more careful because errors in nomenclature seem to stick forever, as in the word Cocopalm. Many books still insist that coco comes from *kokkos*, the Greek for seed, and there is apparently no reason for it except the superficial similarity of the words. When L. named the genus Cocos he probably had the word coccus in his mind.

The serious business of naming persons and places is even more haphazard. A colored woman in Key West liked the name "Dora," but it was too common in her neighborhood. A naval officer for whom she worked suggested "Cuspidora" in a joke. The child was so christened and is probably the only person in all the world with such a name. No doubt many plant and animal scientific names have a similar basis.

JOHN C. GIFFORD

SPECIAL CORRESPONDENCE

THE ADVANCEMENT OF GEOLOGY THROUGH COOPERATIVE RESEARCH

BECAUSE it has become evident that the advancement of the geological sciences requires the cooperation of a number of highly trained specialists, a geological expedition is now being organized to make a comprehensive study of the exceedingly interesting region just north and east of Yellowstone National Park. According to the plans formulated federal and state agencies, universities, research organizations and individual scientists will cooperate in the threefold plan of training students, conducting scientific research and studying mineral deposits which may be found to have commercial value.

Work planned for the present summer includes airplane and topographic mapping by the War Department and U. S. Geological Survey, and geological field work by the Montana Bureau of Mines and Geology and the U. S. Geological Survey; and during 1931 gravity studies will be made in the region by the U. S. Coast and Geodetic Survey in an effort to compare and harmonize geological and geodetic evidence afforded by the area.

Preliminary studies of the geography, land forms and glacial geology of the Beartooth Plateau and adjacent lowlands will be made jointly by Professor Nevin M. Fenneman, of the University of Cincinnati and National Research Council; by Professor Paul McClintock, of Princeton and the Illinois State Geological Survey, and probably by Dr. Arthur Bevan, who was formerly at the University of Illinois, is now state geologist of Virginia and did his thesis work for the University of Chicago on the physiography of the Beartooth region.

Study of the Cambrian geology of the region, which is a continuation of the work of the late Dr. Charles D. Walcott, of the Smithsonian Institution, will be directed by an informal committee consisting of Dr. C. E. Resser, of the U. S. National Museum; Dr. Ira Edwards, of the Milwaukee Museum, and Professor B. F. Howell, of Princeton. Work on special details of local Cambrian geology is to be done by Gordon Knox Bell, Jr., of New York City, a graduate of Harvard and at present a graduate student at Columbia University.

Work on the chromite deposits and other ore deposits of the Beartooth region, and on the intrusive and volcanic rocks of the area, will be planned by a group including Dr. C. H. Clapp, president of the University of Montana; Dr. Francis A. Thomson, president of the Montana School of Mines and director of the Montana Bureau of Mines and Geology; Professor A. F. Buddington, and Professor Edward Sampson, of Princeton. Special phases of the petrologic work will be taken up by Dr. E. L. Perry, of Williams College.

The underground water resources of the Montana portion of the area will be studied by Dr. Eugene S. Perry, of the Montana Bureau of Mines and Geology, assisted by students from the Montana State School of Mines; and the coal and oil geology of the region will be studied in a broad way by Dr. C. E. Dobbin, of the U. S. Geological Survey; and by Dr. W. T. Thom, Jr., of Princeton, who is a participant in the research work of the American Petroleum Institute

and American Association of Petroleum Geologists, besides being a member of the National Committee engaged in the scientific classification of North American coals.

The study of the structure of the mountains and subsidiary folds of the region will be planned by a group including Dr. Thom; Professor Walter H. Bucher, of the University of Cincinnati; Professor Chester R. Longwell, of Yale, and Professor Rollin T. Chamberlin, of the University of Chicago.

The fossil plants associated with the volcanic deposits lying east of the Yellowstone Park, or included in the river-laid clays of the Big Horn Basin badlands, will be collected and studied by Dr. Erling Dorf, with the advice of Dr. R. W. Chaney, of the Carnegie Institution, and Dr. David White, of the U. S. Geological Survey. Dr. Dorf has been assisting Dr. Chaney for several years in the study of the Pliocene floras of the Pacific Coast sponsored by the Carnegie Institution of Washington, and the doctor's thesis recently submitted by Mr. Dorf to the University of Chicago covered a part of these paleobotanic studies and is being published by the Carnegie Institution.

Study of the processes of marine and continental sedimentation as illustrated by the sedimentary forms of the Big Horn Basin region will be developed by Professor R. M. Field, of Princeton, as a continuation of his studies of sedimentation now taking place in the Bahamas and Florida east coast areas. Dr. Field, together with the other members of the International Summer School of Geology and Natural Resources, will visit the Yellowstone and Big Horn Basin regions this summer. Foreign guests of this year's summer school include: Dr. Frank Debenham, head of the department of geography of Caius College, Cambridge University; Dr. H. Schneiderhöhn, professor of economic geology and director of the Mineralogical Institute of the University of Freiburg; Dr. P. Ramdohr, professor of mineralogy of the Mineralogical Institute of Aachen; Dr. Otakar Matousek, associate professor of methods of geology, Charles IV. University, Prague, Czechoslovakia.

Administrative direction of the field research work is under the direction of Dr. Thom, acting with the advice of Professor J. P. Rowe, chairman of the department of geology at the University of Montana, and of Professor Field as director of the International Summer School. Doctors Dorf and Perry will participate as executive assistants as well as scientific investigators.

A cabin colony will probably be established in 1931 at some strategic point along the eastern or northeastern foot of the Yellowstone Park Plateau. This colony will serve as headquarters both for the students who are receiving practical training and for the experienced geologists who may wish to spend their summers in group study and research in the Yellowstone-Big Horn Basin province.

Through the prosecution of plans laid out by such a group of scientists, it seems certain that geology will be advanced as a science and that a popular understanding of geology and an appreciation of the work of the federal and state surveys will both be promoted to an appreciable degree.

W. TAYLOR THOM, JR.
RICHARD M. FIELD

PRINCETON UNIVERSITY

SCIENTIFIC BOOKS

Mathematical and Physical Papers. SIR JOSEPH LARMOR. In two volumes. Vol. I, pp. xii + 679; Vol. II, pp. xxxii + 811. Cambridge University Press, 1929.

THESE two large beautifully printed volumes contain one hundred and four papers on mathematics and mathematical physics as well as nearly fifty additional notes or papers in the form of appendices, a few of which follow the papers to which they refer but most of which are collected at the end of each volume. Nine papers relating to physical relativity have been omitted from the collection, since the author felt that their significance has been vitiated by more recent developments of the subject. The following rough classification of the one hundred and four numbered papers gives an idea of the range of Professor Larmor's interest. In mathematics without direct physical applications there are nine papers of which six are predominantly in the field of geometry. Twelve papers fall in the domain of dynamics, several of them having to do with celestial mechanics or geophysics; the theory of elasticity claims three, and hydro and aerodynamics seven. Relating to thermodynamics, statistics and atomic theory there are eight papers. The largest categories, however, are electromagnetism, including the ether, and optics. Although it is not possible to distinguish sharply between these two, we may classify thirty-seven as belonging to the former and twenty-two to the latter. Then there are three obituaries or appreciations (Gibbs, Kelvin, John Michell), a paper on the periodicity in sun-spots, an address before the British Association in 1900 on the "Methods of Mathematical Physics" and the presiden-

tial address delivered before the London Mathematical Society in 1916.

Professor Larmor's most valuable contributions to science were made in the golden age of classical physics, and his papers abound in references to Faraday, Ampère, Helmholtz, Carnot, Clausius, Kelvin, Maxwell, Stokes, Kirchhoff, Boltzmann, Gibbs and Rayleigh. The last half of the nineteenth century and the early years of the present century was a period in which the ether held sway as the most controversial and devastating subject with which theoretical physics had to deal. For this reason the most interesting papers in this collection are those dealing with the properties of this suppositious medium. These papers appeared during the years from 1894 to 1897 under the title "A Dynamical Theory of the Electric and Luminiferous Medium." Part I outlined the broad underlying principles of the theory; Part II developed the theory of electrons, and Part III, relations with material media. Impressed by Kelvin's remarks, in connection with Stokes' suggested explanation of the aberration of light, that the motion of the ether outside of matter must be of an absolutely irrotational character, Larmor took for his dynamical model of the ether a medium with rotational elasticity such as that which had been proposed by MacCullagh in 1839 in the effort to give a rational basis to Fresnel's discoveries in optics. On this theory electric fields are explained as strains in the medium, magnetic fields as velocities. MacCullagh's ether, like Kelvin's quasi-labile ether, yields equations of motion identical in form with the electromagnetic equations. Therefore the proper dynamical application of either of these ether models must lead to the same results as Maxwell's equations. Larmor, however, introduced a new element in his hypothesis of 1895 that electricity exists in the form of discrete charges—electrons. In this series of monographs he deals not only with those phenomena—such as propagation of light in isotropic and anisotropic materials—which depend only on the macroscopic properties of the medium, but also with phenomena such as dispersion which involve its microscopic structure. Finally he does not ignore the optics of moving media.

Among other important contributions, that numbered fifty-one has perhaps proved of the greatest significance in connection with modern atomic theory. This paper, entitled "On the Theory of the Magnetic Influence on Spectra; and on the Radiation from Moving Ions," was published in December, 1897. It is the one in which Larmor's Theorem, familiar to every student of the theory of the Zeeman effect, is developed. This theorem is vital on account of its generality, for it enables us to assert that the dynamics of the electrons in an atom—no matter how complicated the structure may be—is the same relative to rotating axes in the presence of a magnetic field as relative to fixed axes in its absence, provided only that second order terms are negligible.

These collected papers of a great mathematical physicist of the age when classical physics was at the height of its power constitute an important addition to the library of every student of the subject, and should have a place on the shelves of every departmental library.

LEIGH PAGE

A Chemical Dictionary, containing the words generally used in chemistry, and many of the terms used in the related sciences of physics, astrophysics, mineralogy, pharmacy and biology, with their pronunciations, based on recent chemical literature. By INGO W. D. HACKH, Professor of Chemistry, College of Physicians and Surgeons, School of Dentistry of San Francisco, California. Pp. 790. P. Blakiston's Sons & Co. Inc. Philadelphia, 1929.

THAT an individual should have undertaken, apparently singlehanded, to produce a book containing thirty to fifty thousand concise definitions of chemical and other scientific terms, portraits and a brief statement about the work of a considerable number of chemists and a short discussion of many of the most fundamental principles of chemistry seems almost incredible. The result is a book which is sure to prove very useful to chemists and to physicists, biologists, physicians and many others who make use of the facts of chemistry. No similar book has been attempted for more than a century.

The following illustrations of the varied and detailed information found in the book will give some indication of its value:

A table of alchemical and chemical symbols in parallel columns; a list of a dozen substances used in drying gases with accurate statements of the efficiency of each; the structural formulas of camphor, morphine, brucine, cocaine, nicotine, strychnine and dozens of other natural and synthetic alkaloids; list of the minerals containing nickel; table giving the composition of ten kinds of milk; a half-column about vitamins; diagram of the radioactive disintegrations.

Professor Hackh has long been known as a chemist with fresh and original ideas of his own, not always in accord with orthodox chemistry. These ideas are worthy of consideration and study and they are not obtruded in such a manner as to interfere seriously with the usefulness of the book.

In the opinion of the writer "univalent" and "bivalent" are more common American usage than "monovalent" and "divalent." There are some differ-

ences of opinion about this, however. The latter terms are mixed Greek and Latin. It is, of course, impossible to avoid errors in fact and some errors in proof in such a voluminous work. Users of the book who discover such errors will confer a favor both to the author and to future users of the book if they will notify Professor Hackh of such mistakes.

W. A. NOYES

UNIVERSITY OF ILLINOIS

The Oedogoniaceae. By L. H. TIFFANY. 253 pp., 64 pl., 25.5 x 17 cm. Published by the author, Columbus, Ohio, 1930.

THE algal flora of North America has been most incompletely explored, the modern studies mostly resulting in more or less elaborate local floras rather than general works. Regarding marine algae the situation is being materially improved, especially on the west coast, and a comprehensive monograph of North American diatoms has appeared, but the present work is different in character from almost anything else dealing with algae attempted in this country.

This monograph is expected to initiate a series of revisions of the groups of filamentous algae. The author is fortunate in dealing with a very distinct and highly specialized group, and has utilized the great diversity of form and stature presented to give concise and decisive keys to the many species. The great difficulty which a phycologist always meets in dealing with a large genus in its world-wide distribution, namely, the intergrading of a multitude of minor forms, seems to have been very effectively dealt with. Two of the genera, Bulbochaete (48 spp.) and Oedogonium (195 spp.), are large, with many varieties, but Oedocladium is small, three of its four species resting on the largely unpublished work of I. F. Lewis. Nearly ten pages are devoted to a description of cell structure and the reproductive organs, and these give essential aid in the interpretation of the morphological peculiarities of the family. The description of cell division and the reproductive processes is more complete and modern than is elsewhere available. With data probably unequaled the writer discusses the habitats and periodicity of the major genera over the north central states area he, in conjunction with E. N. Transeau, has studied closely. Maxima in May and June are reported, with a few species showing in a second generation an October maximum. The length of time required to reach a normal full maturity, rather than subsequent environmental conditions, seems most significant in determining the time of fruiting. The family Oedogoniaceae is retained in the group Stephanokontae of the Chlorophyceae following the suggestion of Blackman and Tansley. By far the greatest bulk of the book is necessarily devoted to the systematic treatment of the various species and varieties, with the usual synonymy, descriptive data and distribution well and fully presented, though it would seem that a convenient grouping of countries was not followed. The critical notes care for changes of interpretation and close comparisons, and almost all the plants described are illustrated, mostly original, by redrawing of the original figures, or figures from some other authoritative source. Some seven novelties are described, but the discoveries of the author have largely been previously reported. Since the volume has no geographical limits, it is sure to be the standard reference work on the family for many years, and for all countries.

WM. RANDOLPH TAYLOR

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MANIFOLD DESICCATING APPARATUS FOR DETERMINING THE DRY WEIGHT OF SMALL SAMPLES OF WOOL[1]

THE desiccating apparatus discussed in this paper has been successfully used for some time in determining the dry weight of small samples of wool in connection with making determinations of the density in fleeces, that is, the number of fibers in a given area. Methods for taking these samples have been previously discussed by Burns,[2] Hultz[3] and Nordby.[4] Burns and Hultz have also discussed the method of calculating the number of fibers in the samples taken.

In determining the density in wool, samples .25 square inch in area are usually taken in different parts of the fleece. Each sample is thoroughly cleansed and treated with a yolk solvent, such as ether, and then air-dried. A definite number of fibers is counted out of each sample and weighed. The balance of the sample is also weighed. The total number of fibers in the original sample is calculated by dividing the weight of the original sample (sum of two weights) by the weight of the fibers counted, and

[1] Approved for publication by the director of the Idaho Agricultural Experiment Station as Paper 67.

[2] R. H. Burns, "Some Phases of Wool Inheritance in F_1 Generation," *Proc. Am. Soc. An. Pro.*, 1924; "Wool Analysis Density Determination," *Wool Rec. and Textile World*, V. 30, No. 902, 1926.

[3] Fred S. Hultz, "Wool Studies with Rambouillet Sheep," Univ. Wyo. Agr. Exp. Sta. Bul. 154.

[4] Julius E. Nordby, "The Idaho Wool Caliper and Its Application in Making Density Determinations," Ida. Agr. Exp. Cir. No. 52.

multiplying this result by the number of fibers in the counted sample. It is obvious that the most uniform results are available by desiccating to dryness the wool samples and the bottles in which the samples are kept.

The most satisfactory method used in this laboratory for driving moisture from wool is by means of passing heated air through the sample. Inasmuch as the water present in wool has a vapor pressure less than that of water under normal conditions it is obviously essential to heat the wool above the boiling-point of water in order to drive the contained moisture off as vapor. Barritt and King[5] made use of this principle in making comparisons of the actual moisture content of wool, referred to as true regain, with the commercial regain in an apparatus described by Barker and Hedges[6] and illustrated by King.[7]

The warm air distributing unit (Fig. 1) used with

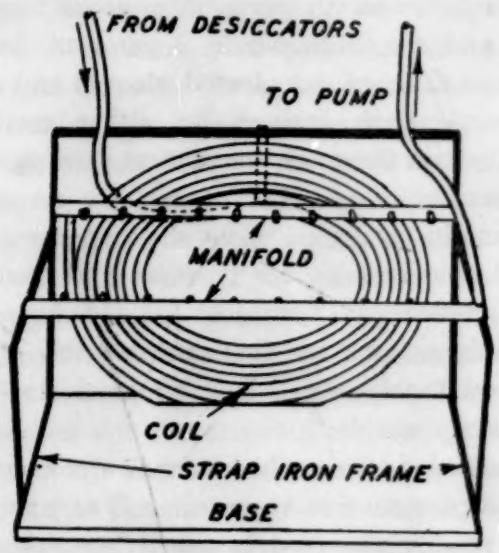


FIG. 1

this apparatus is adapted to a standard 18 x 12 x 14 inch, 220 V. electric oven. It is a removable unit composed of a steel frame into which are mounted a coil, made from twenty feet of one fourth inch copper tubing, and two brass manifolds each having ten three sixteenths inch jets. These manifolds are mounted in the steel frame in such a way that the bottles containing the wool samples (in this case U tubes with ground glass stoppers tightly fitted) may be attached to the jets by means of short pieces of a high-grade rubber tubing, which will maintain flexibility for two determinations. The air inlet and outlet of the unit pass through the ventilators in the oven top and extend above it sufficiently for outside connections.

[5] J. Barritt and A. T. King, *Jour. Text. Inst.*, 1926.

[6] S. G. Barker and J. J. Hedges, "Notes on the Determination of the Dry Weight of Wool." British Research Association for Woolen and Worsted Industries, Bul. No. 64.

[7] A. T. King, "The Determination of the Regain of Small Samples of Wool." British Research Association for Woolen and Worsted Industries, Vol. 1, No. 3, 1930.

The desiccators used are concentrated H_2SO_4, $CaCl_2$ and $Mg(ClO_4)_2$, all of which are provided in suitable containers for efficiently desiccating the air before it enters the heating unit. The air is drawn through the apparatus by means of a filter pump. Arrows in the accompanying figure indicate the direction of air movement. The desiccating efficiency of the H_2SO_4 has been enhanced by introducing the air through small perforations in bulbs blown into the glass tubing.

The temperature of the oven is raised to 105° C. before the filter pump is put into action. A two-way stopcock between the desiccating train and the oven makes it possible to run undesiccated air through the wool. This is done for fifteen to twenty minutes and is effective in removing the bulk of moisture from the wool samples, after which the air is passed through the desiccating train for approximately thirty minutes. The time required to reduce the samples to constant weight depends somewhat upon the rate of air movement through the apparatus which can be controlled by the filter pump and a stopcock between the filter pump and oven.

A mercury vacuum tube (Fig. 2) is part of the equipment and is very useful in operating the ap-

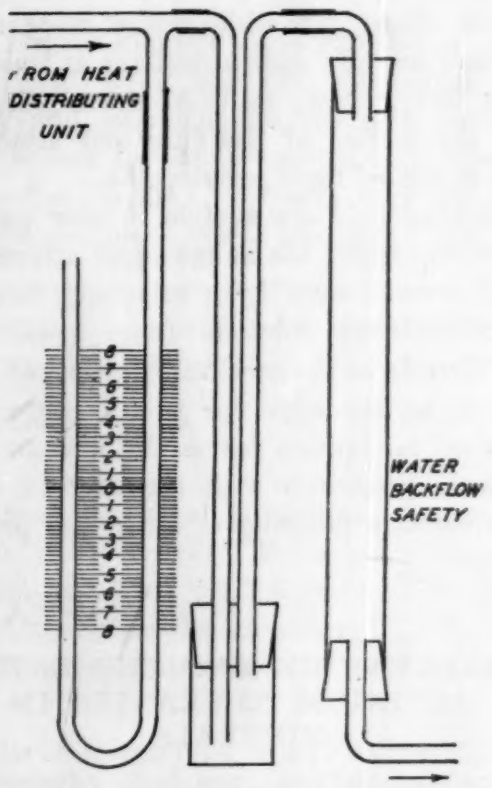


FIG. 2

paratus. It acts as an indicator of the air flow. The mercury trap stops any backflow of air into the wool samples. In the event the filter pump should suddenly stop there is a sufficient amount of mercury in the trap to satisfy the vacuum in the apparatus before the mercury supply in the trap is exhausted.

An additional safety factor, in the form of a one inch glass tube, is installed to accommodate any backflow of water between the mercury trap and filter pump.

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THE PREPARATION OF PERMANENT SLIDES OF THE RHIZOPOD ARCELLA

HEGNER[1] has recently described a convenient method for fixing and preserving specimens of the shelled rhizopod Arcella. By his method, Schaudinn's alcoholic-acetic-sublimate is poured over the animals while they are attached to the bottoms of Petri dishes, and clearing and preserving are effected by the use of glycerin.

We use a similar method in the preparation of slides of Arcella in our protozoology course, and it is believed that a note upon the method will be of interest, for it supplements Hegner's method in that it concerns the staining of the arcellas as well as their fixation. The procedure follows.

The arcellas, together with several drops of fluid, are transferred from a hay-infusion stock culture to clean micro slides. The slides are set aside in a moist chamber and are left undisturbed for at least half an hour. In this interval, many of the arcellas usually settle to the bottom of the fluid and attach to the slides by means of their pseudopodia.

The surplus fluid on a slide is now poured off. This operation leaves the animals still attached to the slide and covered only by a relatively thin film of fluid. Schaudinn's solution (used cold) is now dropped directly on the arcellas by means of a pipette and is left on the slide for two or three minutes. This method of fixation leaves the animals attached to the slide, frequently with pseudopodia extended. Thus the common difficulty of cementing protozoa to the slide is circumvented by the behavior of the arcellas themselves.

The slide is now ready for staining, and in this process it is treated entirely like a histological preparation. It is immersed in succession in the following fluids: 70 per cent. alcohol, made light brown by the addition of tincture of iodin (to remove sublimate), 30 minutes; 50, 25 per cent. alcohol, water, 1 to 3 minutes in each; dilute Delafield's hematoxylin (1 part stock Delafield to 3 parts water), 5 to 10 minutes; water, 25, 50, 70, 95 per cent. alcohol, absolute alcohol, equal parts absolute alcohol and xylol, pure xylol, 1 to 3 minutes in each; balsam.

If desired, Heidenhain's iron hematoxylin may be used instead of Delafield's. In this case, after fixation and treatment with iodin, the slides are hydrated, and are then mordanted an hour in 4 per cent. ammonio-ferric sulphate (iron alum). They are stained at least four hours in 0.5 per cent. aqueous hematoxylin solution and are destained in 2 per cent. iron alum, after which they are dehydrated, cleared and mounted.

In preparations stained by either method, the nuclei, of which there are two in most species, each with a conspicuous central karyosome, are revealed with diagrammatic clearness. The shell aperture and the extended pseudopodia are likewise well shown. Arcella is particularly favorable for the demonstration of chromidia, and by this method the chromidial bodies—commonly overlooked by students—are rendered clearly visible.

In conclusion, the method affords a convenient procedure for demonstrating certain cell organelles which are not readily observed in the living animal. Furthermore, the permanency of such preparations makes them available for class study or demonstration at times when living arcellas are not immediately obtainable.

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SPECIAL ARTICLES

ACTINO-URANIUM AND THE RATIO OF ACTINIUM TO URANIUM IN MINERALS

VARIOUS speculations have been advanced in the past about the origin of actinium.[1] However, the experimental evidence in all cases is fundamental. This evidence is (*a*) Boltwood's original work[2] on the "constancy" of actinium to uranium in several uranium-bearing minerals from North Carolina, all presumably of the same age; (*b*) the very important recent work of Aston on the relative intensities of the mass spectral lines Pb_{208}, Pb_{207}, Pb_{206} from the lead isotopes of a bröggerite from Karlhus, Raade, Norway,[3] and also Aston's similar work on the ordinary lead,[4] and (*c*) the observations of various investigators that the relation of actinium to uranium seems to vary somewhat in minerals which may be of different ages. Among these the most recent work is that of Wildish.[5]

Rutherford[6] using Aston's data and making certain

[1] Robert Hegner, *Trans. Am. Micr. Soc.*, 48: 214, 1929.
[1] Résumé in *Radioactivity Bull. N.R.C.*, No. 51, 1929.
[2] B. B. Boltwood, *Am. J. Sci.* [4] 25: 269–298, 1908.
[3] F. W. Aston, *Nature*, 123: 313, 1929.
[4] F. W. Aston, *Nature*, 120: 224, 1927.
[5] James E. Wildish, *J. Am. Chem. Soc.*, 52: 163–177, 1930.
[6] Sir Ernest Rutherford, *Nature*, 123: 313, 1929.

assumptions deduced the half-value period of actino-uranium as $T = 4.2 \times 10^8$ years.

Piggot[7] expressed the opinion that if the relative intensities of the lead isotope lines 208, 207, 206 are known the age of the mineral can be accurately determined. He was instrumental in having the bröggerite lead and also the ordinary lead material prepared for Aston's analysis. On the basis of Aston's results on the bröggerite lead and their own chemical analysis of the mineral from which the lead was obtained, Fenner-Piggot[8] calculated the age of the mineral considering the 208, 207, 206 intensities as indicative of the relative amounts of Th D, Ac D and Ra G. They found, however, that the ages calculated on the basis of the uranium content and on the basis of the thorium content were in great disagreement. When one considers the probable error given by Aston for the intensities and also the small amount of thorium, one would expect some disagreement. However, any common lead present will introduce a very serious error in the calculations on the basis of the thorium content because the Pb_{208} line in the ordinary lead is one half of the total intensity, and if it is considered (in the calculations) as of Th D origin the age must come out greater than it should, and since the Th amount is relatively small, the error is proportionately greater.

In the work of the committee on the age of the earth of the National Research Council, I have frequently pointed out the error of neglecting the possible presence of common lead. I have developed formulas for the calculation of this amount and the age of the mineral basing the equations on the two fundamental facts, namely: I. The sum of the atoms of common lead (L), Ac D, Ra G, Th D equals the number of atoms in the lead isotopes found in the mineral; II. The sum of the masses of the common lead (L), Ac D, Ra G, Th D is equal to the total mass of the lead isotopes; and, of course, using the radioactivity equations of disintegration and of equilibrium. If the actinium series is considered as a branch from U II the equations obtained are

$$\frac{1.20\,U}{238.17}\cdot(e^{\lambda_u\cdot t}-1)-\frac{0.80\,Th}{232.15}\cdot(e^{\lambda_{th}\cdot t}-1)=Pb\cdot\left(\frac{207.20-A}{A}\right)$$

and

$$L=207.20\left[\frac{Pb}{A}-\frac{U}{238.17}\cdot(e^{\lambda_u\cdot t}-1)-\frac{Th}{232.15}\cdot(e^{\lambda_{th}\cdot t}-1)\right]$$

in which U, Th, Pb and L are masses in grams of uranium, thorium and lead isotopes, and ordinary lead, respectively; and for the atomic weights: A refers to the lead isotopes and 206, 208 are used for Ra G (also Ac D) and Th D respectively. These equations presented at the Washington meeting of the American Physical Society in 1929[9] will be published in the report of the National Research Council committee and also in the *American Journal of Science*.

In this case L represents accurately the amount of common lead. If, however, the actinium descends from actino-uranium, an independent isotope of uranium, some Ac D is included in the value L and also a part of Ac D is included with Ra G. The part with Ra G depends on the actinium: uranium ratio, r. Then, if $u \equiv$ number of atoms of uranium, $r \cdot u$ in final disintegration would be actinium lead atoms. The amount of Ac D thus considered with Ra G is

$$\frac{r\cdot U}{238.17}\cdot(e^{\lambda_u\cdot t}-1)\cdot 206.$$

This correction can be readily made when we are certain of this lineage and also of the value of the ratio, r.

Using Fenner-Piggot's analysis data, namely, $U = 61.158$, $Th = 4.377$ and $Pb = 8.018$, and Aston's $A = 206.19$, and assuming $r = 0.03$ and making the above corrections for Ac D we obtain for the age of this bröggerite $t = 825 \times 10^6$ years and for $L' = L +$ Ac D $= 0.986$ gm per 100 gm mineral. Now,

$$\text{Ra G}=\frac{0.97\,U}{238.17}\cdot(e^{\lambda_u\cdot t}-1)\cdot 206=6.856$$

$$\text{Th D}=\frac{Th}{232.15}\cdot(e^{\lambda_{th}\cdot t}-1)\cdot 208=0.176$$

Using Aston's relative intensities Pb_{206}: Pb_{207}: $Pb_{208} = 100 : 10.7 \pm 3 : 4.5 \pm 2$ we get $Pb_{206} = 6.960$, $Pb_{207} = 0.745$ and $Pb_{208} = 0.313$ gram. For the ordinary lead Aston gives the intensities I_{206}: I_{207}: I_{208} = 4 : 3 : 7. Hence we can write

$$Pb_{208}=0.313=\text{Th D}+\frac{1}{2}L\ (\text{ord. lead})=0.176+\frac{1}{2}L \quad \ldots\ (1)$$

$$Pb_{207}=0.745=\text{Ac D}+\frac{3}{14}L \quad \ldots\ (2)$$

$$Pb_{206}=6.960=\text{Ra G}+\frac{2}{7}L=6.856+\frac{2}{7}L \quad \ldots\ (3)$$

and

$$\text{Ac D}+L=0.986 \quad \ldots\ (4)$$

[7] C. S. Piggot, *J. Wash. Acad. Sci.*, 18: 269–273, 1928.
[8] C. N. Fenner and C. Piggot, *Nature*, 123: 793–794, 1929.
[9] A. F. Kovarik, *Phys. Rev.* [2] 33: 1069–1070, 1929.

The amount of common lead can be calculated separately from (1), (3) and (2) + (4) and comes out

$L = 0.274$ from (1)
$L = 0.364$ " (3)
$L = 0.307$ " (2) and (4).

In view of the probable errors in the intensities, these results for the amount of common lead must be considered quite satisfactory.

It is evident, therefore, that in calculating either the age of the mineral or the disintegration constant of actino-uranium one must take into consideration the ordinary lead present in the mineral. That common lead may be present in bröggerites has also been shown by Professor Ellen Gleditsch.[10]

The ratio, r, of actinium: uranium is really defined by the equation

$$r \cdot \lambda_u \cdot u = \lambda_{ac} \cdot ac = \lambda_{ac\,u} \cdot ac\,u_t = \lambda_{ac\,u} \cdot ac\,u_o \cdot e^{-\lambda_{ac\,u} \cdot t} \quad \ldots . (I)$$

in which u and ac refer, respectively, to the number of uranium atoms and the number of actinium atoms under conditions of radioactive equilibrium. In experimental work in which r was determined, the whole of uranium was taken as U, and hence

$$u = \frac{U}{238.17} \cdot N \quad \ldots . (II)$$

in which U is the mass of all the uranium and N is Avogadro's number.

If $ac\,u_o$ and $ac\,u_t$ represent, respectively, the number of atoms of actino-uranium present in the mineral initially and at the time, t (time of analysis), and since Ac D is the final product of actino-uranium, then

$$\frac{Ac\,D}{207} \cdot N = ac\,u_o \cdot (1 - e^{-\lambda_{ac\,u} \cdot t}) \quad \ldots . (III)$$

From the equations (I), (II) and (III) we obtain

$$\frac{Ac\,D}{207} = (\lambda_u \cdot \frac{U}{238.17} \cdot r) \cdot \left(\frac{e^{\lambda_{ac\,u} \cdot t} - 1}{\lambda_{ac\,u}}\right) \quad \ldots . (IV)$$

Substituting into (IV) values given above and using $\lambda_u = 1.52 \times 10^{-10}$ yr^{-1} and $r = 0.03$ we get

$$\lambda_{ac\,u} = 2.5_4 \times 10^{-9}\ \text{yr}^{-1},$$

or

$$T_{ac\,u} = 2.7_3 \times 10^{8}\ \text{years}$$

If we may assume that the relative amount of actino-uranium to uranium (I + II) is initially the same in all uranium-bearing minerals (an assumption offering some difficulties) then this relative amount should change with the progress of time and r should be less in older minerals at the time of the analysis. The results below show that such a variation seems to exist.

Let t′ be the age of the mineral for which $r = 0.03$ and t be the age of the mineral for which $r = 0.08$, then

$$\frac{r_{t'}}{r_t} = \frac{e^{\lambda_u \cdot \Delta t}}{e^{\lambda_{ac\,u} \cdot \Delta t}} = \frac{0.03}{0.08} = \frac{e^{1.52 \times 10^{-10} \cdot \Delta t}}{e^{2.54 \times 10^{-9} \cdot \Delta t}}$$

from which $\Delta t = t' - t = 4 \times 10^8$ years.

Boltwood, who obtained $r = 0.08$, used the North Carolina uraninites (Spruce Pine), and Hahn-Meitner, whose $r = 0.03$, used "pitchblende." Ages of the minerals are not given. Kirsch, whose value of r is 0.04 and more nearly like that of Hahn-Meitner's value, used Morogoro pitchblende and also a bröggerite from Raade, Moss, Norway, whose age is, at least approximately, 8 or 9×10^8 years. The determination of the age of a North Carolina uraninite (Flat Rock Mine) yields a very much lower age. If the ages were accurately known, it is not improbable that the difference in age may be such as to account for the different value of the ratio obtained by Boltwood and by Hahn-Meitner or by Kirsch or by S. Meyer.

Two minerals, namely, uraninite from Keystone, South Dakota, and uraninite from Sinyaya Pala, Carelia, supply data which with some assumptions, reasonable for these two minerals, may be used to produce a check on these deductions. The ages of these minerals by the above "age formula" come out, respectively, 1465×10^6 yr and 1852×10^6 yr and the corresponding values of L (= ordinary lead + some Ac D) are 0.67 and 0.91. Considering the great ages of these minerals and also the relatively more rapid rate of disintegration of actino-uranium than of uranium, it is highly probable that a greater part of the "L" is Ac D in the case of these minerals. In any case the error will not be great to assume this. Correcting also Ac D by a fraction

$$\frac{r \cdot U}{238.17}(e^{\lambda \cdot t} - 1) \cdot 206$$

we have

$$Ac\,D = L + \frac{r \cdot U}{238.17} \cdot (e^{\lambda_u \cdot t} - 1) \cdot 206$$

$$= 207 \cdot (\lambda_u \cdot \frac{U}{238.17} \cdot r) \cdot \left(\frac{e^{\lambda_{ac\,u} \cdot t} - 1}{\lambda_{ac\,u}}\right) \ldots . (A)$$

which can be solved for r. We can also calculate r from the difference of age of the mineral under consideration and the age of a mineral for which $r = 0.03$. For the latter age we may use the approximate value 8×10^8 years. We get

[10] Ellen Gleditsch, *Skrift. Norsk. Vidensk. Akad. Oslo*, No. 3, pp. 1–49, 1925.

$$r = 0.03 \cdot \left(\frac{e^{\lambda_u \cdot \Delta t}}{e^{\lambda_{ac\,u} \cdot \Delta t}} \right) \quad \ldots . \text{(B)}$$

in which Δt = age of mineral considered minus 8×10^8 years.

The essential data for these minerals are:

Keystone, S. D., uraninite:
$U = 66.90$, $L' = 0.67$, $t = 1465 \times 10^6$ yr.

Sinyaya Pala, Carelia:
$U = 61.41$, $L' = 0.91$, $t = 1852 \times 10^6$ yr.

The results of such calculations are:

Mineral	r from (A)	r from (B)
Uran. Keystone, S. D.	0.0053	0.0061
Uran. Sinyaya Pala	0.0027	0.0024

We see that the two calculated values in the case of each mineral check reasonably well. It is also evident that r for the Keystone mineral is a little more than ½ per cent. and for the Sinyaya Pala about ¼ per cent. It is to be noted also that the difference of age of these two minerals is roughly 4×10^8 years. Considering these results it would be desirable to have the experimental values of r from these minerals.

The following general conclusions about actino-uranium seem plausible:

(1) Actino-uranium seems to be an independent isotope of uranium.

(2) Its disintegration constant is about $\lambda_{ac\,u} = 2.5 \times 10^{-9}$ yr^{-1} or $T = 2.7 \times 10^8$ years.

(3) Its amount in minerals appears to conform to the idea that it is initially of a definite amount in proportion to the uranium and that this relative proportion decreases with the age of the mineral.

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ON THE MECHANISM OF BIOLOGICAL OXIDATION AND THE FUNCTION OF THE SUPRARENAL GLAND

CLINICAL and experimental observations on the symptoms of suprarenal deficiency have indicated that the suprarenal gland is in some way involved in the mechanism of oxidation. For this reason I have studied for many years processes of oxidation, with the hope of finding the clue to the function of the cortical part of the gland. Vegetable tissues were used in these studies to a great extent.

Most of the common plants and fruits can be divided into two main groups: those which show discoloration on injury (apple, banana, potato), and those which do not (lemon, orange, cabbage).

Extending earlier observations of Palladin and M. W. Onslow, it was found[1] that the most prominent oxidation system of tissues which discolor on injury is the so-called phenoloxidase system. This system consists of a phenoloxidase and a phenol, which latter is a derivative of catechol and is chemically closely related to epinephrin. In the presence of molecular oxygen, this phenol is oxidized by the phenoloxidase to an ortho-quinone. In the intact tissue, this quinone is rapidly reduced by hydrogen, which is derived from the foodstuffs. If the tissue is injured, this reduction does not take place; the quinone remains in the oxidized state and undergoes secondary changes, or combines with other cellular constituents. The quinones and their secondary products are highly colored and thus cause discoloration of the tissue.

It is known that quinones have a very high bactericidal power. It has been shown in the latest experiments on potatoes that injury to the tissue leads to increased oxidation of the phenol and therefore to increased production of quinones, so it seems probable that the phenoloxidase systems also play a part in the natural immunity of plants which contain this oxidation system.

Most vegetable tissues which do not have the phenoloxidase system and which do not discolor on injury contain a highly active peroxidase and very little catalase. Further investigation has shown that these tissues also contain, in relatively high concentration, a substance which is characterized by its strong reducing properties. This substance has been isolated in crystalline form and has been found to be a hitherto unknown compound related to the carbohydrates. This acid is an isomer of glucuronic acid and has been named "hexuronic acid." This acid shows quite unexpected activity. It reduces salts of silver even in the cold and in an acid solution. It is the most reactive derivative of the carbohydrates hitherto discovered and prepared in free condition.

The most striking property of this substance is its reversible oxidizability, by which two of its hydrogen atoms can be split off in a reversible way. The substance owes its high reactivity to these two labile hydrogen atoms, and not to the carbonyl group.

The latest studies performed on cabbage leaves have brought out the fact that in this plant hexuronic acid plays a central rôle in normal respiration. It has been shown that the cabbage leaf contains a very active enzyme which oxidizes hexuronic acid at a high rate, oxidizing off its two labile hydrogen atoms. The oxidized hexuronic acid is then again reduced. In this way, the hexuronic acid connects as a hydrogen car-

[1] A. Szënt-Györgyi, "Über den Oxydationsmechanismus der Kartoffeln," *Biochem. Ztschr.*, 162: 399–412, 1925.

rier, on the one hand the oxidation systems which utilize oxygen, and on the other the foodstuffs which are the source of hydrogen.

The enzyme responsible for the rapid and reversible oxidation of hexuronic acid has been called "hexoxidase." Its properties are different from the properties of other known oxidizing enzymes. Study of the kinetics of this enzyme has clearly shown that this enzymic function is a complicated one and that the hexuronic acid is not immediately oxidized by the enzyme. The enzyme contains a special substance or grouping, "x," which is first oxidized by the oxygen. This oxidized "x" then in turn oxidizes the hexuronic acid and is itself reduced again. No cyan-sensible oxygen activation is involved in the oxidation of "x," so that this oxidation probably goes hand in hand with the formation of hydrogen peroxide. This would explain the presence of the highly active peroxidase which would complete the system, utilizing the peroxide thus formed.

Extending these studies to the suprarenal gland, it was found that the suprarenal cortex contains a strong reducing agent, the high concentration of which is sharply characteristic for this organ. This substance has been isolated in crystalline form and has been found to be identical with the hexuronic acid from plants.

Hexuronic acid completely inhibits formation of pigment in all systems in which a "melanoid" pigment is formed through the oxidation of a phenol. In biologic systems a minimal concentration of hexuronic acid is sufficient to give complete inhibition. The absence of hexuronic acid in Addison's disease could give thus a clear explanation of the mechanism of formation of pigment.

Experiments, however, performed on animals after extirpation of the suprarenal glands, have shown that hexuronic acid is unable to prolong life. Hexuronic acid given in two cases of Addison's disease seemed to have some beneficial effect but did not restore the patients to full activity. It seems to be certain, therefore, that besides hexuronic acid some other substance is elaborated by the suprarenal cortex to which this organ owes its vital importance. The formation of pigment, however, which in Addison's disease is not dependent on the gravity of the case, seems to be connected with hexuronic acid. It seems to be highly probable that the other hitherto unknown product of the cortex plays in the animal tissue a part analogous to that of the "x" substance of the oxidation system of the cabbage leaf, which has been mentioned.

The careful survey from a chemical standpoint of reducing substances of the suprarenal gland also has brought out the fact that the medulla contains, besides epinephrin, a strong reducing agent which is specific for the medullary tissue. The substance has not yet been isolated. In many ways its behavior is analogous to that of hexuronic acid, but it seems not to be identical with it. This substance also inhibits formation of pigment, and it is possible that its absence also is a factor in the production of pigmentation in Addison's disease. It is possible that both reducing substances, hexuronic acid and the reducing substance of the medulla, play an important part in the stabilization of the other active principles present (epinephrin and the unknown hormone of the cortex). It can easily be shown *in vitro* that epinephrin is highly autooxidizable at the hydrogen-ion concentration of the tissue. The oxidized molecule rapidly undergoes irreversible secondary changes. In the presence of hexuronic acid or in the presence of the reducing substance of the medulla the oxidized molecule of epinephrin is at once reduced again and is protected in this way from secondary irreversible changes.

There are thus four specific substances elaborated by the whole suprarenal gland. In the medulla are found epinephrin and a strongly reducing substance. In the cortex are found hexuronic acid and the probable presence of another active principle, the existence of which seems to be established by the recent work of Hartman and his collaborators, of Stewart and Rogoff and by the most recent investigation of Swingle.

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BOOKS RECEIVED

PHILLIPS, E. G. *A Course of Analysis.* Pp. viii + 361. 35 figures. Cambridge at the University Press. 16s.

RABINOWITSCH, DR. E. *Grundbegriffe der Chemie.* Pp. 151. 2 figures. Walter de Gruyter & Company. RM 1.80.

SHAW, NAPIER. *Manual of Meteorology.* Volume III. The Physical Processes of Weather. Pp. xxviii + 445. 149 figures. Cambridge at the University Press.

STANDING, HERBERT F. *Spirit in Evolution from Amoeba to Saint.* Pp. 312. 44 figures. Dial Press. $5.00.

TIMOSHENKO, S. *Strength of Materials.* Part I. Elementary Theory and Problems. Pp. xii + 368. 299 figures. Van Nostrand. $3.50.
Part II. Advanced Theory and Problems. Pp. xi + (401–735). 175 figures. Van Nostrand. $4.50.

WHEELER, RAYMOND H. *Readings in Psychology.* Pp. x + 597. Illustrated. Crowell. $3.75.

WHITE, LEONARD D. Editor. *The New Social Science.* Pp. ix + 132. University of Chicago Press. $1.50.

THE ĀRYABHATIYA OF ĀRYABHATA. *An Ancient Indian Work on Mathematics and Astronomy.* Translated with Notes by Walter Eugene Clark. Pp. xxix + 90. University of Chicago Press. $2.50.

LONGWELL, CHESTER R. *Outlines of Physical Geology.* Prepared from the Third Edition of Part I of a Textbook of Geology by the Late Louis V. Pirsson, Charles Schuchert. Pp. v + 376. 275 figures. Wiley. $3.00.